MARINE BOILERMAKING PRACTICE

Bulletin 345-T

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Vocational Training
for
War Production Workers

Cylindrical Tanks Loaded for Shipment

MARINE BOILERMAKING PRACTICE

(A Manual of Instruction for Beginning and Advanced Marine Boilermakers)

Bulletin 345-T

Prepared by the

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF PUBLIC INSTRUCTION
DIVISION OF INDUSTRIAL EDUCATION

In Cooperation With

SUN SHIPBUILDING AND DRY DOCK COMPANY
CHESTER, PENNSYLVANIA

SCHOOL DISTRICT, CITY OF CHESTER
CHESTER, PENNSYLVANIA

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Foreword

The many recent developments peculiar to the work involved in modern boilermaking practice, the necessity for training large numbers of war production workers in the fabrication of steel shapes and tanks, and the erection of marine boilers have prompted the development of this publication.

The units in this manual have been organized and developed with the assistance of experienced foremen and mechanics, men who are specialists in boiler-shop fabrication, in the erection of marine boilers, and in the general repair of the various units.

The procedures presented are specifically those which are followed in the yard of the Sun Shipbuilding and Dry Dock Company. Many of the methods and procedures will be found applicable in training boiler-shop workers and marine-boiler erectors for other shipbuilding situations where these classes of mechanics are employed.

Acknowledgment is made to the Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania, for assistance and cooperation in making the preliminary analysis and in preparing instructional materials.

Special acknowledgment is extended to George D. Carney, General Superintendent in charge of Mechanical Installations; Howell Chetty, General Foreman of Boiler Shop; John Wilkinson, Jr., Boiler Erector Leader; Joseph Cregg, Assistant Foreman, Boiler Shop; and A. J. Fox, Assistant Foreman, Boiler Shop, for materially assisting in the preparation of text material, sketches, and photographs. These men served as technical advisers during the preparation of this manual.

Appreciation is extended to the Chester School District, to D. Francis Hallowell, Coordinator of Chester Area Vocational Training for War Production Workers, and to William A. Brock, Area Coordinator of Industrial Education, for assistance in this work.

This manual of instruction was prepared at the Chester Field Curriculum Laboratory of the Pennsylvania Department of Public Instruction. Charles Johnston, Adviser, Division of Industrial Education, supervised the preparation of materials at the Laboratory. This work was completed under the direction of Charles F. Zinn, Adviser, Division of Industrial Education, and under the general supervision of Paul L. Cressman, State Director of Vocational Training for War Production Workers.

Francis B. Haas
Superintendent of Public Instruction

July, 1943

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PART I
SAFE PRACTICES IN BOILERMAKING

Introduction

Industrial accident reports show that careless workmen are responsible for the majority of injuries which occur. Accidents do not happen. Accidents are caused. Industrial plant managers know this and have spent considerable time and money to carry on safety campaigns and install safety devices for the prevention of accidents. In spite of all this, some workers, after being told repeatedly to wear goggles, to keep guards on machines, to look where they are going, to be careful always, and not to leave obstructions where they can cause injuries, etc., still persist in doing as they please.

It is quite common to hear an accident victim say "I did not see", or "I did not know", or "I did not think". One who thinks in terms of safety is a safe worker. Accident prevention demands that a mechanic be on the alert whether on the job or off the job.

The loss of an eye, a limb, or health may impair the usefulness of a mechanic in his trade or occupation. In going up and down ladders the mechanic should face the ladder. In climbing a scaffolding tower or using the accessible hand and foot holes of a structure, he should make certain of good handholds and sure footings. He should keep his balance at all times while working on scaffolding and make a practice to avoid awkward positions during all operations performed while on a scaffold. Wire-hung scaffolding should be anchored with tie ropes to prevent swaying.

Tools, equipment, and materials of various kinds are raised and lowered on the job by means of ropes. The ropes must be tied securely, and they must be in good condition. Many forms of slings and lifting devices are employed for certain jobs. The workmen should make certain that all fastenings are secure. and that wire cables are free from defects and kinks. He should never use connected shackles where additional length is required for lifting a load; he should procure a wire rope sling of the proper length.

Always keep entirely out from under lifted loads. Any load is likely to slip or break loose. In hooking or tying loads, always use a wire cable sling in preference to a chain. When eyebolts are used for hooking to heavy loads, the bolt should be screwed down full to the eye. If threads will not permit this, use washers or nuts as spacers. Keep cables as nearly vertical as possible.

When working on boilers where one boiler has steam on, before opening up be sure that the valves do not leak. In some cases, blanks have to be used in the boiler

feed line, auxiliary steam line, and the blow-down line. Be sure to remove blanks when the job is finished. When working on boilers, one of which has steam on, the man in charge of the job should lock the connecting valve between the boilers with a chain and padlock.

Never use two hand hammers or two sledge hammers against each other. If necessary to use a handle tool, secure a backing-out hammer or set hammer to place against the work. When hand hammers or sledge hammers are hit together, because of their degree of hardness a piece is likely to chip off and cause personal injury.

A. Physical Examination Requirements

1. Good health.
2. Good heart.
3. Ability to climb.
4. Ability to get through a 12″ x 16″ opening (Moderate size and weight).

B. Keeping Physically Fit for the Job Requires:

1. Plenty of sleep.
2. Proper food.
3. Abstinence from liquor.

Proper Care of Eyes

1. Eyes are priceless. Guard them well.
2. When foreign substances do get into the eyes, go to the dispensary for proper care at once.
3. When an eye injury is received, or when some foreign substance gets into the eye, under no circumstances allow a fellow worker to "fix it up" or "get it out". He may be a first-class boilermaker, but a poor oculist.
4. Always wear goggles when chipping. grinding, or burning.
5. Do not try to learn welding by looking at the electric arc of a welder. It cannot be learned that way, and the ultra-violet ray of the arc will cause a "flash" or a burn of the eye.

Typical Shipyard and Boiler-Shop Hazards

Burning Hazards

1. Remember that a burning torch burns metal and that it will burn flesh much more easily. Avoid the flame.
2. Before doing any burning, make sure that you know who or what is on the other side or below the work and avoid causing injuries.
3. Wear goggles to protect the eyes from hot metal.
4. Make sure that gas and oxygen connections are tight.
5. Keep gas and oxygen hose clear of hot sparks and molten metal.
6. Do not lay a lighted torch down.
7. Do not hold a lighted torch in the hand while telling Joe of the good time you had the night before; give the other fellow a chance.

8. Wear heavy gloves to prevent burning the fingers and hands.
9. After burning, wash the hands thoroughly before eating.
10. Do not leave a torch in a small, unventilated enclosure. Gas might leak and cause an explosion when the torch is relighted.
11. Do not burn metal in such a position that when a piece is burned off it will fall and cause injuries. See Fig. 1.

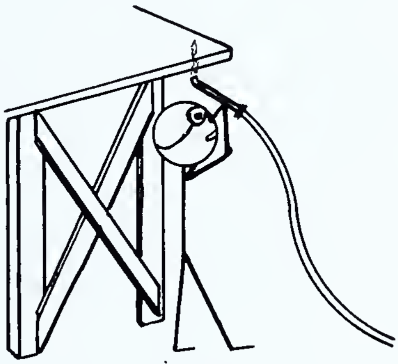


FIG. 1 — *Keep From Under When Burning*

Chipping Hazards

1. Wear goggles while chipping. Many cases of blindness have resulted from careless exposure of eyes to flying particles of metal.
2. Use sharp tools when chipping. A dull tool only slows the chipping and increases fatigue.
3. Wear gloves when chipping. The hammer might slip and cause a flesh wound and sub sequent infection.

Compressed-Air Hazards

1. Shut off air at the manifold when finishing work with the chipping hammer. Do not tie up the end of the lead hose. Many nasty accidents have been caused by a "lashing" air hose.
2. Do not use compressed air to blow the dust off clothing. Compressed air is dangerous when improperly used.
3. Do not leave a compressed-air hose line where it may be cut through by a heavy falling object or burned through by close proximity to heat. When the air-hose line is suddenly cut or burned through, the pressure of the escaping air may cause injury by blowing dirt into a person's eyes, or blowing fire against clothing that might ignite. This sudden release of air also sometimes causes the air-hose line to whip; an accident may result.

Danger of Falling

1. Unsafe footing.
2. Presence of objects which would make footing hazardous, such as scrap or oil.
3. Insecure staging, spawls, or other working supports.
4. Improper treatment of guard-rails.
5. Improper shoes.
6. Hose, burning and welding lines, electric feed wires.
7. Failure to replace staging which has been moved.

Danger From Falling Objects

1. Exceeding safe working loads of equipment which may result in breakage.
2. Insecure fastening of loads.
3. Poorly applied or unsafe lifting pads.

4. Leaving loose objects where they may slide off the job or staging.
5. Leaving tools in precarious positions.
6. Danger of dropping tools while using them.
7. Danger of dislocating planks, small parts, or other objects in swinging a load with a crane.
8. Carelessly throwing scrap from the job.
9. Improper shoring.
10. Working under loads being lifted or erected.

Danger From Inadequate Personal Protection

1. Loose clothing, especially pant legs.
2. Lack of safety shoes where necessary.
3. Lack of safety helmets where necessary.
4. Lack of proper eye shields around welding.
5. Taking foolhardy risks.
6. Improper use of tools and equipment.
7. Daydreaming.

Make sure the hoist is hung to a solid member of sufficient strength to hold the load which it is to carry.

See that the lashing, choker, sling, shackle, or clamp used is of sufficient strength to hold the load.

Use a chain hoist of correct capacity.

Wire rope slings are generally used in hoisting. In using slings of any kind, care must be taken to see that one section does not lie on top of another and thus put an undue strain on the outer section.

Clothing Hazards

1. Boilermakers' work is naturally dirty. Do not allow overalls to get so greasy that a spark will ignite them.
2. Do not wear ragged clothes. They will get caught on sharp edges, or cause a fall.
3. Keep fingers and arms away from sharp edges.
4. Do not wear gloves when operating machinery. Do not fool around machines with which you are not familiar. Mind your own business.

Steam or Hot-Water Hazards

1. Do not turn off, or on, valves with which you are not familiar.
2. When blowing down a boiler for inspection, make sure it is completely empty before opening it.
3. Make sure that all handhole caps and manhole covers are tight.
4. Do not use worn-out or nicked gaskets.
5. When working on boilers hooked in a series, make sure that steam lines hooked to the boiler on which the work is being done are blanked off.

Handling Material

When the workman is moving large apparatus, methods of handling are of prime importance. Each piece of apparatus must be handled with reference to its special construction. Practically all of the handling of the larger machines and parts is done by the riggers and the crane hook-on or signal man. One should become familiar with the correct methods of handling such material.

There is a great difference between ropes and slings used for hoisting. The wear in ropes can be seen by frayed, loose, or cut strands. A chain, except for a few bruises, will not show any signs of weakness, although it may be full of small cracks which cannot be seen, or by long use it may be crystallized to a great extent.

Care should be used in every case to see that satisfactory slings and ropes are used to lift the load.

Removal of any staging or beams should be arranged for in advance with the proper departments, i.e., stage builders, shipfitters, or erectors.

Have the piece available for slinging under a crane where it can be lifted. Have adequate chain hoists and other gear ready, to avoid lost time holding the load.

Care of Tools and Equipment

1. Do not use defective tools.
2. When welding keep tools clear of the work. Do not attempt to weld initials or

Fig. 2 — *Safety Devices and Accessories*

other markings on a tool. The heat will crystallize it and cause it to break under a strain.

3. Do not use a ⅝″ wrench and a shim to tighten a ½″ nut. Skinned fingers will be the result. Use the correct size of wrench.
4. Pull on a wrench. Do not push with the hand closed. If it is necessary to push, use the palm of the hand.
5. Make sure that handles in hammers and mauls are tight.

Safety Appliances and Accessories

The safety department engineers have studied the causes of accidents and how to best prevent them. There is no substitute for common sense and the workman's exercise of carefulness on every job. The safety department, however, has procured every known safety device for the use and the protection of the workman. These devices are available through the safety department and they must be used at all times while working on the job.

Safety devices and accessories are shown in Fig. 2.

The gloves shown at 1 are to be worn when handling boiler plate. The palms of the gloves are leather and protect the hands from steel slivers and the rough edges.

The gloves shown at 2 are to be worn while doing chipping and other similar work. The gloves prevent bruising of the hands if the chisel or hammer should slip.

Fig. 3 — *All-Purpose Gas Mask*

The rubber-covered electric extension cord shown at 3 should be used at all times when artificial light is necessary. The guard should completely cover the globe.

The safety shoes, one of which is shown at 4, should be worn by all men working in the boiler shop. A pressed-steel cap (5) in the toe of the shoe prevents serious injury if a heavy object falls on the toes.

Respirators should be worn when grinding. A respirator (6) must always be worn when repairing a boiler that has been used. The respirator shown at 7 is suitable when doing ordinary grinding.

Safety hats (8) should be worn by all boilermakers as a protection against falling objects and to avoid injuries caused by bumping the head against projections and obstructions.

The goggles shown at 9 should be worn when doing chipping and grinding. The protecting side screens keep dust and grit from getting into the eyes. The goggles shown at 10 are for general use when drilling, knocking out rivets, using a bobbing tool, calking, etc. Keep the glass clean. A cleaning cloth is provided for that purpose.

Acetate shields (11) are available to all workmen who use grinding wheels for a prolonged period. They are more comfortable and give better protection than goggles.

The all-purpose gas mask shown in Fig. 3 should be kept readily available at all times to be worn by the man who may have to enter a boiler to remove a workman when the workman has been overcome by fumes.

The gas-mask outfit shown in Fig. 4 is a fresh-air mask and it is to be worn when a man descends into a tank to do repair work or to assist in the removal of others who have been overcome by the gas which is always likely to be present. The air hose is long enough to extend into the tank and the

FIG. 4 — *Fresh-Air Mask*

FIG. 5 — *Safety Belt*

helper pumps fresh air to the man inside of the tank. The reinforced case shown in Fig. 4 contains a rotary air pump which is operated by a crank. A constant supply of fresh air is pumped to the workman wearing the mask.

The safety belt shown in Fig. 5 is worn by a workman who must descend into a tank to do repair work, or to clean the tank. Should the workman need aid quickly the man or men at the top can speedily hoist him out of danger. The man on the outside keeps a hold on the rope at all times. Never enter a tank without proper protection.

A stretcher should always be readily available in case an injured man must be hurried to the first-aid dispensary. Carry the injured person in a level position and with as little jar as possible. Every workman should be on the alert to render any assistance necessary when a fellow workman needs help. Quick action may save a life.

FIG. 6 — *Canvas Army-type Stretcher*

PART II

TOOLS AND EQUIPMENT

Tools the Boilermaker Is Expected to Own

1. Adjustable wrenches
2. Angle gauge
3. Center punch, prick punch
4. Chalk line, 200 ft. long
5. Combination square
6. Dividers
7. 50′ diameter conversion tape
8. Fifty-foot steel tape
9. 4″ outside calipers
10. Hammer, ball peen, 2-lb. 1½-lb., ½-lb.
11. Hand spring-clamps
12. 24″ level
13. Plumb bob and line
14. Scriber
15. Six-foot folding rule, wood or steel
16. Trammels
17. 24″ steel square

Company Owned Tools and Equipment Which Are Kept in the Tool Crib

1. Automatic platelifting grabs
2. Blue or white chalk
3. Calking tools
4. C clamps
5. Complete set of steel stamps (letters and figures)
6. Compound tube-expanding machines
7. Drifts
8. Drilling machines (Air or electric)
9. Drills
10. Expanders and mandrels
11. Files
12. Flanging mauls
13. Hack saws
14. Cold Chisels
15. Impact wrenches
16. Lead hammers
17. Marking-paint pots.
18. ¼″ marking brushes
19. Portable grinders
20. Pneumatic air hammers
21. Pneumatic chipping hammers
22. Pneumatic-hammer chisels
23. Pneumatic "holder-on"
24. Pneumatic surface grinders
25. Pneumatic wire brushes
26. Punches and shears
27. Riveting tools
28. Roughing tools
29. Soapstone pencils
30. Socket wrenches
31. Snips
32. Special clamps
33. Spud wrenches
34. Straightedges
35. Tongs
36. Wedges
37. Tube expanders
38. Two-foot measuring wheels
39. Y-branch connections
40. Hand hammer

Care and Use of Tools and Equipment

Six-Foot Folding Rule

Six-foot folding rules, either metal or wood, are often used to advantage. With care, very close measurements may be taken. The 12 sections of the rule fold up into a small bundle about 7½ inches long, 3 to 3½ inches wide, and possibly ¾ of an inch thick, according to the width of the rule. See Fig. 7.

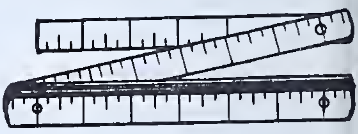


Fig. 7 — *Folding Rule*

Special Features

The folding rule is very useful for several reasons: It may be adjusted at the joints to form an angle; it may be pushed up as high as a man can reach, straight overhead without buckling (as is often the case with a steel tape); or it may be supported at two points along the length while the mechanic steps back to take a sight on some part of the work when he is working alone.

Accuracy of the Folding Rule

A folding rule is not so accurate as a steel tape. When the rule becomes worn at the joints, an error of as much as 3/16 of an inch, in six feet is possible. It is always better, therefore, to use a steel tape when accurate measurements are to be taken. Six-foot rules are graduated to 1/16 of an inch.

Standard Measure

In order for the layout man to have his work agree with the blueprint, he must follow the sizes given and measure from the center lines or other points exactly as indicated. He must use the same type of measuring tool which was used by the draftsman. It follows, then, that all scales are STANDARD; that is, the length of one inch or one foot on one scale is the same length as one inch or one foot on another scale.

Scale Divisions

When we examine a rule, we find there are many marks, or fine cuts, along its edges. These marks are for the purpose of dividing the length of the scale into many equal parts. No matter how long the scale may be, each inch is found to be exactly the same length. If all the work to be measured were an exact number of whole inches in size, a scale divided into inches would serve the purpose. But this is not so.

Reading Measurements

Measurements are given in feet and inches, or in feet, inches, and parts of an inch. For example: A certain plate is ¾ of an inch thick; 1 foot, 2 inches wide; and 2 feet, 4½ inches in length. Another way of saying the same thing would be: ¾″ x 1′ 2″ x 2′ 4½″. The x used here means "by". For example: 2″ x 4″ is read "two by four inches." Sizes are sometimes given in feet and inches; often they are given in inches or parts of one inch.

Reading Measurements Correctly

A boilermaker layout man must be able to read a rule quickly or he is not a good mechanic. He will lose a lot of time and cause others to lose time unless he can read a rule correctly at the first attempt. To read a rule correctly the mechanic must thoroughly understand its markings.

One-Inch Graduations

On a one-foot scale there are 12 inches; so a one-foot scale has 12 equal spaces, but only 11 marks or dividing lines. The lines mark off the spaces. The spaces are called graduations. With the scale indicated in Fig. 8, one can measure as close as one inch.

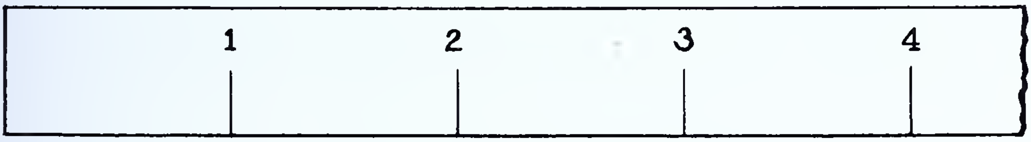


Fig. 8 — *One-Inch Graduations*

The markings on the scale show one standard graduation, or division, which in this case is 1 inch. Of course this scale would be all right to measure even inches, but

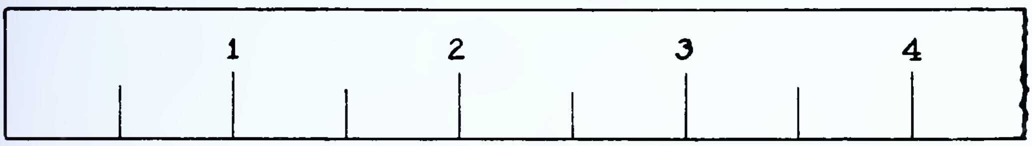


Fig. 9 — *Half-Inch Graduations*

anything less than one inch could not be measured. Marking off each division or graduation into half-inches overcomes this objection. See Fig. 9.

Half-Inch Graduations

Now the markings on the scale show two graduations, or divisions, of the same length in one inch. This scale can be used to measure as close as $\frac{1}{2}$ inch. But the work has to be measured much closer than $\frac{1}{2}$-inch; therefore the graduations or divisions must be made still finer.

Quarter-Inch Graduations

The markings on the scale (Fig. 10) show four graduations, or divisions, of the same length in one inch. This scale could be used to measure as close as $\frac{1}{4}$ inch.

Fig. 10 — *Quarter-Inch Graduations*

Eighth-Inch Graduations

The markings on the scale (Fig. 11) show eight graduations, or divisions, of the same length in one inch. This scale could be used to measure as close as ⅛ inch.

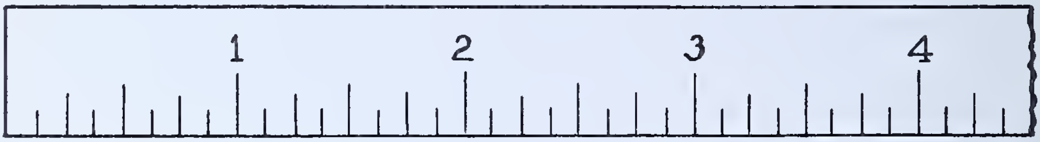


Fig. 11 — *Eighth-Inch Graduations*

Sixteenth-Inch Graduations

The markings on the scale shown in Fig. 12 indicate sixteen graduations or divisions, of the same length in one inch. This scale can be used to measure as close as 1/16 inch.

This is as close a reading as is found on a 6′ rule.

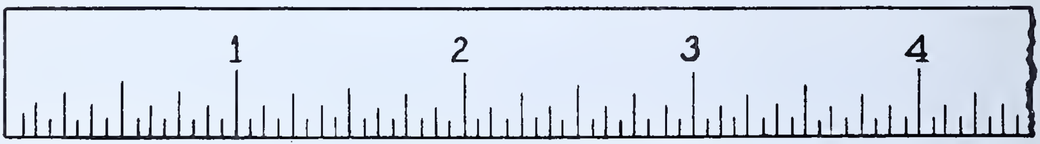


Fig. 12 — *Sixteenth-Inch Graduations*

Fifty-Foot Steel Tape

Steel tapes are usually 50 feet long. Very long measurements are taken with a fifty-foot steel tape. These tapes must be used correctly, or faulty measurements will result. On the end of the tape, there is a loop of steel wire. See Fig. 13.

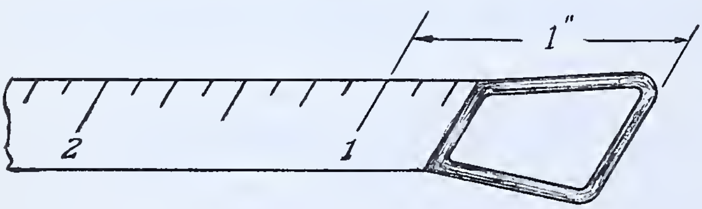


Fig. 13 — *Loop End of Fifty-foot Steel Tape*

The thin, steel ribbon winds up into a casing. Some casings have an inside spring which helps to wind up the tape.

Caution

Notice that it is *one inch* from the *outside end of the loop* to the figure 1 on the tape. This loop keeps the tape from becoming lost in the casing when the mechanic winds it up after using. Always measure from the outside end of the loop. Do not allow the loop to become folded over or under.

Fifty-foot steel tapes are graduated in FEET AND INCHES on one side and in INCHES only on the opposite side. For long measurements the "inches" side of the tape is used frequently. The blueprint usually gives a dimension as 117½″ rather than 9′ 9½″. Much time is saved, and mistakes are avoided by measuring with the "inches" side of the tape.

All steel tapes used where accuracy is required must be checked each week with the tape belonging to an official of the company and kept by him for this purpose. Some mechanics check their tapes twice a week on regular days, Monday and Thursday, before starting work on those days. To make the check, reel out the official's tape far enough to check the total footage to be used on a specific job. Run out the tape to be checked, place the zeros of the two tapes even, and check the highest foot mark required by the job with a foot mark on the official's tape. If they correspond exactly, the checked tape may be put into use. If there is any discrepancy at the highest foot mark, do not use this tape for accurate work.

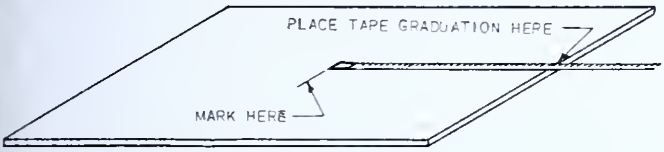


FIG. 14 — *Make the Mark at the End of the Loop*

Never walk on a tape, and never drop anything on it; it is a fragile, sensitive tool.

Never use a tape near a welder while he is welding, for the arc may, and often does, "short" through the tape and burn it, thus ruining it.

When measurements are to be taken with a steel tape, the best practice is to place the graduation corresponding to the measurement required on the edge of the stock or at the exact point from which the measurement is to be taken and make a mark with a soapstone pencil at the end of the loop. Always center-punch any markings thus made to keep the location from becoming lost when the soapstone mark is blurred by footsteps or by objects dragged across it. Figure 15 shows how the steel tape is used for accurate measuring on a cylinder.

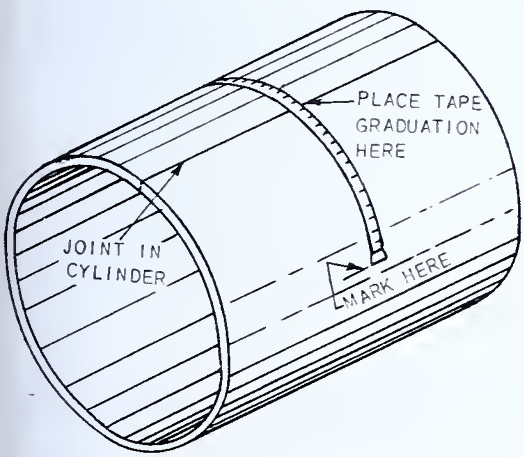


FIG. 15 — *Measuring on a Cylinder*

DIAMETER-CONVERSION STEEL TAPE

An especially graduated steel tape is often used by the boilermaker and the layout man to convert circumferences to their diameters. Figure 16 shows the end of this type of tape, front and back.

The method of using the tape is as follows:

Wrap the tape around a cylinder as shown in Fig. 17. The reading on the tape is 12″, or 1′; and the end, graduated in 64ths, shows a little over 1/4″. Count the 1/64″ graduations carefully, and it will be found that the reading is 20/64″. Reducing 20/64″ to 16ths gives 5/16″. The reading on the tape, then, is 12 5/16″. This is the diameter of the circle, the circumference of which registers at the 1-F (one-foot) and 20/64″ mark on the tape when it is wrapped around the cylinder.

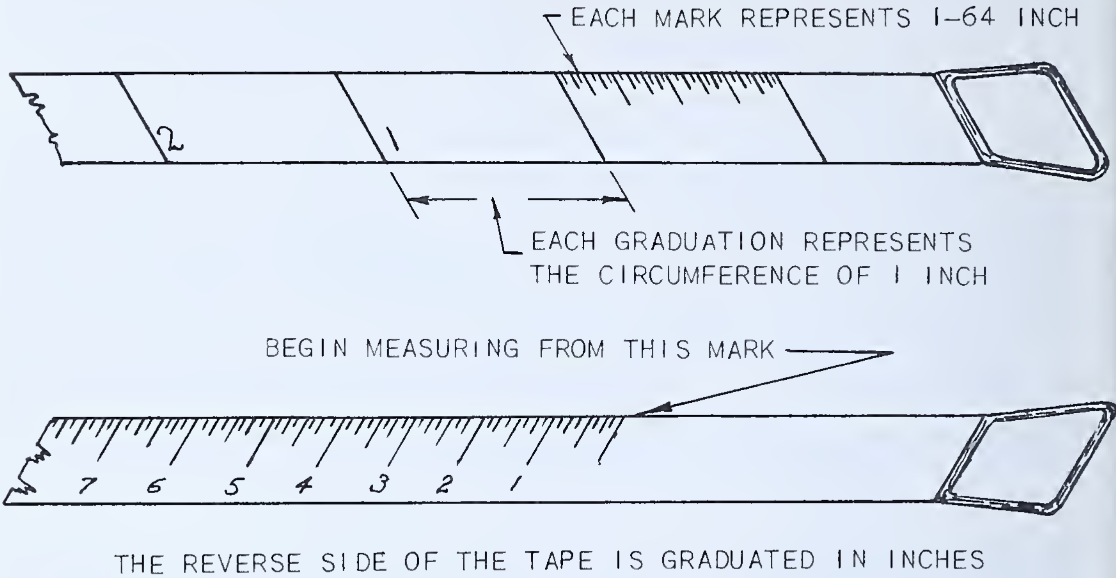


Fig. 16 — *Diameter-Conversion Tape, Showing Front and Back of the Tape*

QUESTIONS

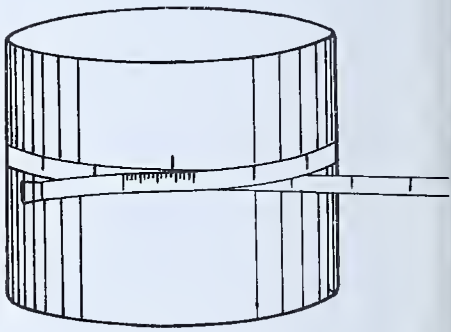


Fig. 17 — *Using Diameter-Conversion Tape*

1. When measuring with an ordinary 50′ tape, does the mechanic take the measurement from the outside or inside of the wire loop?
2. What are the finest graduations on a six-foot rule?
3. Explain the advantages and disadvantages of a folding rule.
4. What precautions are taken when measuring with a fifty-foot steel tape?
5. Is it better to measure from the end of a tape or from a graduation mark when taking a close measurement?
6. Explain how to use a steel tape when taking accurate measurements from the edge of a steel plate or from the joint in a cylinder.
7. Explain the advantages of using a diameter-conversion tape.

TOOLS (*Continued*)

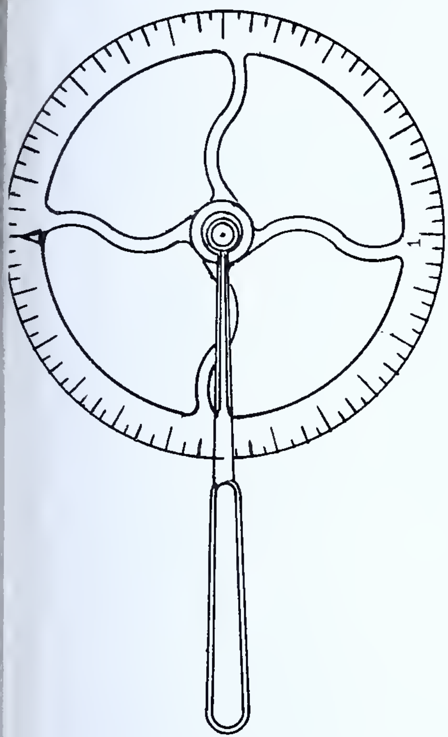


Fig. 18 — *Two-Foot Measuring Wheel*

Measuring Wheel

A measuring wheel is shown in Fig. 18. It is made of metal and fitted with a split handle. The wheel revolves freely in the split handle, and the outside or circumference of the wheel is graduated in feet and inches. The length of the circumference is an even number of feet, such as 1′, 2′, or 3′.

The zero mark, identified by a pointer on the outside edge of the wheel, is placed at any point from which a measurement is to be made, and the wheel is rolled along the surface. The wheel in Fig. 19 measures two feet around the circumference. Five revolutions of the whcel measures ten feet. If the wheel is rolled along for 3½″ farther, the 3½-inch graduation may easily be seen in contact with the surface mark made opposite the 3½″ graduation. Then the total distance measured is 10′ 3½″. The lengths of curved surfaces, the lengths of wavy surfaces, or the distance around the edge of an irregular slope may be measured with the measuring wheel. Care must be taken not to let the wheel slip as it is being rolled. A slip will result in a false measurement.

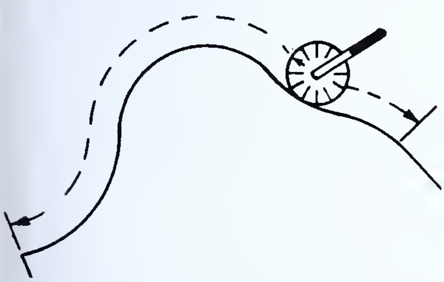


Fig. 19 — *Measuring Curved Edge*

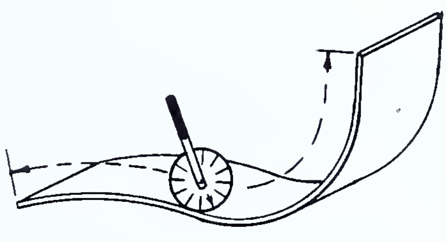


Fig. 20 — *Measuring a Wavy Surface*

Trammels

This tool (Fig. 21) consists of two steel points fastened to metal blocks which slide upon a rod or stick of sufficient thickness to prevent bending. The blocks can be clamped at any point on the rod or stick by the thumbscrews.

Trammels are used to make large circles, to lay off lines at right angles to each other, to check the accuracy of lines that must be at right angles to each other, and to space off equal distances that are too long to be spaced with dividers. Trammels

are shown in Fig. 21. A special trammel leg to be used for scribing circles with soapstone is shown in Fig. 22. One trammel point is removed, and the special leg is inserted in its place.

Dividers

Dividers are used to make circles, to find centers of circles, to divide distances into equal spaces, and to perform other such operations. When the circle to be made is larger than the capacity of the dividers, use a set of trammels.

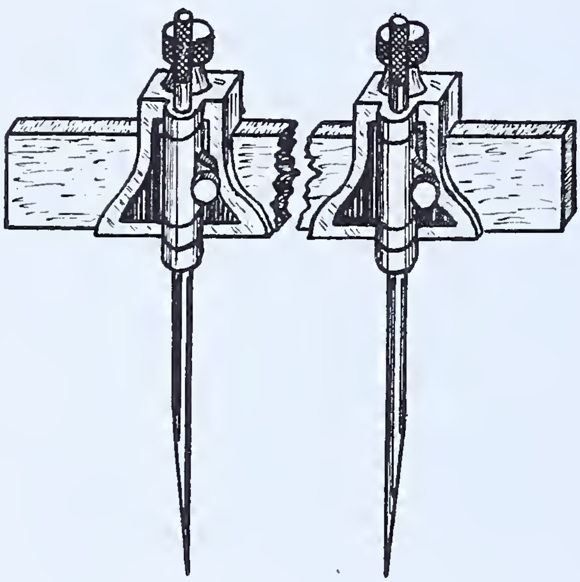


Fig. 21 — *Trammels*

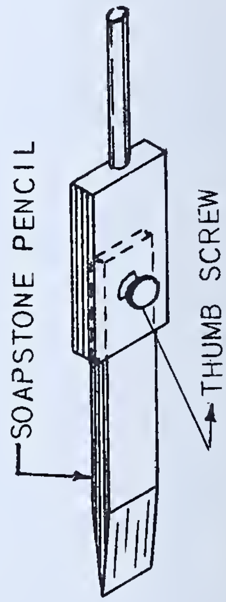


Fig. 22 — *Soapstone-Pencil Insert*

The dividers shown in Fig. 23 are the type generally used for layout work. The legs are adjustable, which allows the tool to be used for doing many jobs that cannot be done with solid-leg dividers.

To obtain the correct setting of the dividers, loosen the wing nut *a* and adjust the divider legs as required. Tighten the wing nut and try the setting for correctness. This is best done by scribing a segment of a circle and checking the distance with a rule.

If an adjustment is necessary, use the two knurled thumb nuts on the threaded end of the adjusting quadrant. By turning one of these nuts in or out, a fine adjustment may be obtained. Tighten the other nut to take up any play, and check the distance again.

To do good work, keep the points sharp. Dull points always give trouble when a workman is laying out a job that must be accurate. Never pick up a pair of dividers

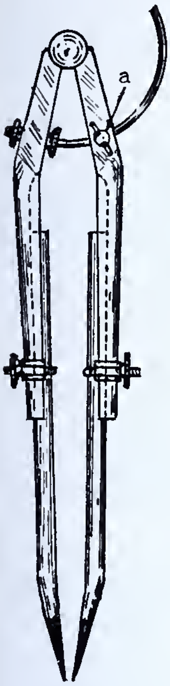


FIG. 23 — *Dividers with Adjustable Legs*

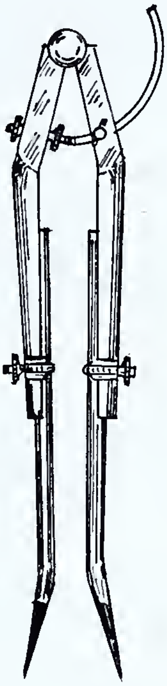


FIG. 24 — *Legs Reversed for Use as Calipers*

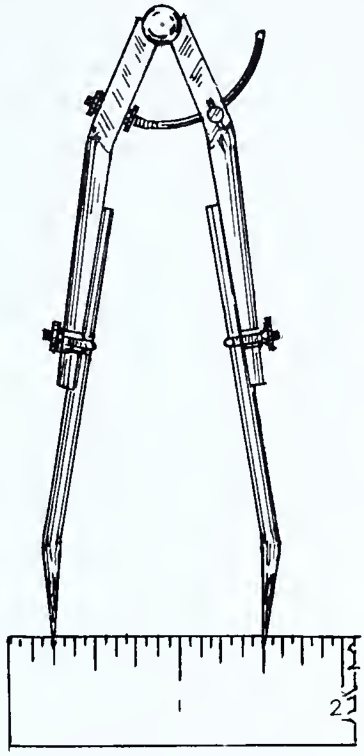


FIG. 25 — *Setting the Dividers to a Scale Dimension*

that someone else has been using without first asking if it is all right to do so.

Someone may have spent valuable time in setting them to the job, and it is often quite difficult to reset dividers exactly.

Figure 24 shows how the adjustable legs can be reversed to throw the points outward so that the tool can be used to caliper inside diameters. One of the adjustable legs can be removed and a pencil substituted. Such an arrangement makes it possible to scribe circles on a piece of paper or wood.

BALL-PEEN HAMMER

A 1½-pound ball-peen hammer is used extensively for hand chipping, center-punch marking, driving driftpins, setting and expanding tubes, cleaning header boiler tubes, cutting a light tube, etc.

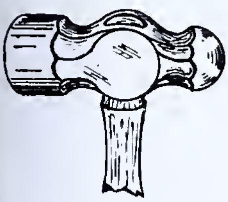


FIG. 26 — *Ball-Peen Hammer*

The principal reason for listing the above operations is to fix in the mind of the student the fact that a hammer has a definite place on the job. The use of a bolt, a bar of steel, or other makeshift should never be considered. Always use a hammer to do these jobs.

A two-pound ball-peen hammer is used for heavy work. A half-

pound ball-peen hammer is used for making marks with a prick punch. If a heavy hammer is used to strike a prick punch, the work will likely be inaccurate and the heavy blow may break the fine point of the prick punch.

Correct Use of the Hammer

A careful study of a hammer will show that the handle is evenly balanced in the head. The length of the handle may vary to suit the individual, but the hand should always grasp the handle close to the outer end and not up at the head end. Holding a hammer close to the head is called "choking the hammer". This is bad practice and causes accidents.

Safety Precautions

Never strike a hardened surface with a hammer. The face and peen of the hammer are hardened, and two hardened surfaces striking together with force may cause the hammer to "spall"; that is, small chips crack off and fly. These flying steel chips may cause eye injury or cuts.

Never use a hammer with a loose handle or a loose "wedge". The wedge is in the end of the handle to hold it tightly in the head.

Never use the handle as a lever with which to lift or pry.

Using the Center Punch and the Prick Punch

Both types of punches are shown in Fig. 27. The prick punch is used for fine layout work. It makes a fine center mark and a light blow with a light hammer is sufficient for the work.

The center punch is used for heavy work. Grasp the punch firmly and hold it

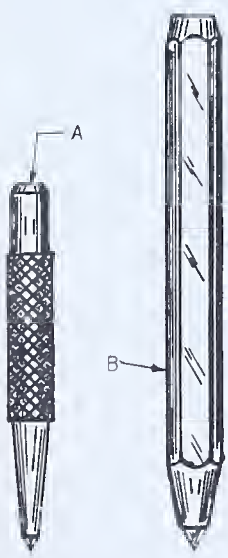


Fig. 27 — *Prick Punch* A *Center Punch* B

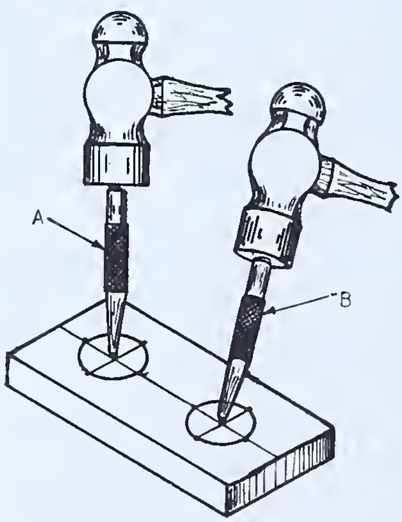


Fig. 28 — *Hold the Punch Vertical*

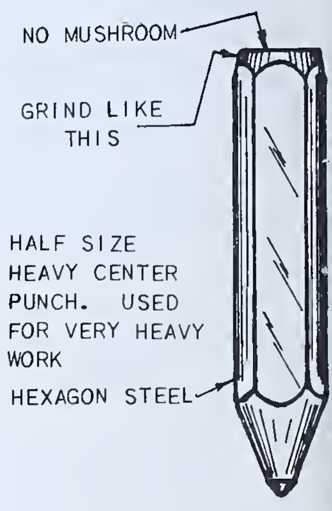


Fig. 29 — *No Mushroom Head*

securely when the blow is struck. If the punch is allowed to slip when struck, it may fly and hurt someone. Strike the punch and not the fingers or hand. See Fig. 28 for the correct position of the punch for making a center-punch mark or a prick-punch mark. The illustration also shows how to "draw" a center-punch mark when it is slightly "off center".

An Example of Using a Hammer

1. When using a center punch (see Fig. 27), one should use a heavier hammer. One blow with a hammer of the right weight is all that is necessary, in most cases. Using a light hammer on a heavy center punch is not permissible.
2. Hold the center punch square with the work. See Fig. 28 at *A*.
3. When using a heavy center punch be sure the mark is "on center". Then set the mark with a heavy blow.

Caution

The top of the center punch will "mushroom" after repeated use. Grind the mushroom off before it spalls and causes injury. See Fig. 29 for an illustration of good practice.

Straight-Peen and Cross-Peen Hammers

Other types of peen hammers are shown in Fig. 30 and Fig. 31. The straight-peen hammer is used for working in a corner where a job calls for the peen to be in line with the hammer handle. The cross-peen hammer is used for working in places where the job can be done better if the peen is at a right angle with the hammer handle.

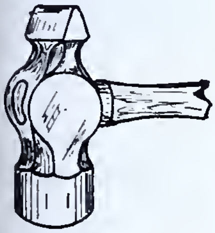


Fig. 30 — *Cross-Peen Hammer*

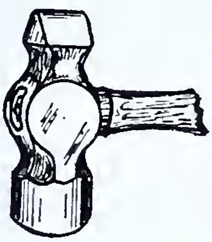


Fig. 31 — *Straight-Peen Hammer*

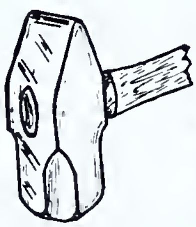


Fig. 32 — *Cross-Peen Maul*

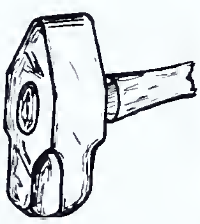


Fig. 33 — *Straight-Peen Maul*

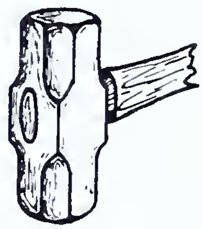


Fig. 34 — *Double-Faced Sledge*

Sledges and Mauls

Sledges and mauls are heavy hammers used by boilermakers and their helpers. They vary in weight from five to twenty-five pounds. A cross-peen maul is shown in Fig. 32. A straight-peen maul is shown in Fig. 33. The peens are made in line with and at right angles to the handle to make it possible to work in close places where the work calls for the use of a straight or cross peen. A double-faced sledge is shown in Fig. 34. Mauls and sledges which weigh from eight to ten pounds are suitable for most of the work. The handles are generally 30″ to 36″ long. The nature of the work

governs the length of the handle. Some handles are only 20″ long; they are usually found in sledges and mauls that are to be used in close quarters.

SET HAMMERS AND FLATTERS

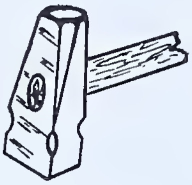


FIG. 35 — *Set Hammer*

Set hammers and flatters are used for smoothing off flat work when finished. The set hammer (Fig. 35) is used for working up into corners and narrow places. The flatter (Fig. 36) is used on wide, flat surfaces. The face of the set hammer used on light work is usually about 1¼″ square. The face of the flatter is about 2½″ square. These sizes vary according to the kind of work which is to be done.

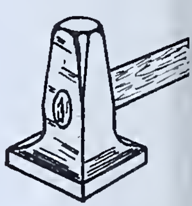


FIG. 36 — *Flatter*

FULLERS

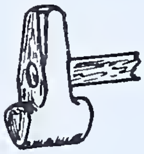


FIG. 37 — *Top Fuller*

The top fuller shown in Fig. 37 is used in the boiler shop for working grooves, working corners inside of angles, and spreading metals at right angles to the working edge of the fuller.

Set hammers, flatters, and fullers are generally used for working hot metal. There are many jobs done which require heating and forming.

TONGS

Holding hot or cold metal pieces securely while forging, bending, or welding them presents a problem which is solved by the use of well-fitted tongs. Tongs must always be fitted to the work. When properly fitted the jaws touch the work as shown in Fig. 38. Fit the jaws by heating them red hot, and grasp the work to be held. Hammer the jaws until they close their full length on the piece. Quench in water.

Tongs which do not fit the work properly should never, under any circumstances, be used.

FIG. 38 — *Properly Fitted Tongs*

After the tongs have been fitted, a link driven over the tong handles (See Fig. 38) will hold the work securely without danger of having the tongs slip off. The link will hold the jaws until it is driven off. The work may be placed in a forge or in an open flame and removed quickly without having to waste time gripping the end of the piece after each heating.

QUESTIONS

1. **Why should a hammer always be used instead of some makeshift?**

2. **State the correct way to hold a hammer and give reasons.**

3. **Explain why a hardened surface should never be struck with a hammer.**

4. **Point out correct practice in using a hammer with a heavy center punch.**

5. **Explain the different uses of a center punch.**

6. **Why is it poor practice to strike hardened surfaces with the face or peen of a hammer?**

TOOLS (*Continued*)

Adjustable Wrench

While the use of a spud wrench (Fig. 39) is always preferable to that of an adjustable wrench, very often an adjustable wrench is more convenient on the job (if there is room to use one) because the adjustable wrench may be quickly changed by a thumb nut to fit a half-dozen different nuts. See Fig. 40.

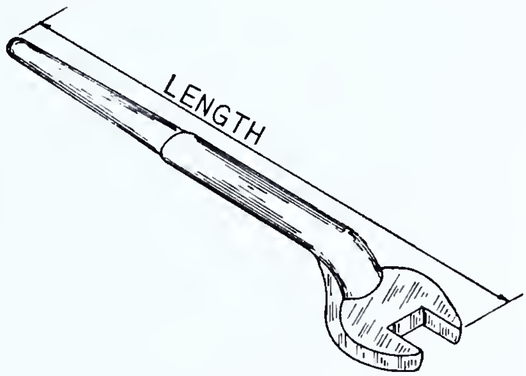


Fig. 39 — *Spud Wrench*

One very bad feature of the adjustable wrench is that it will slip off the nut much more easily than an open-end wrench if it is not constantly watched. The adjustable jaw wears in the groove, and the jaws do not fit the nut tightly. In putting a strain on the wrench always pull if possible in the direction shown in the illustration.

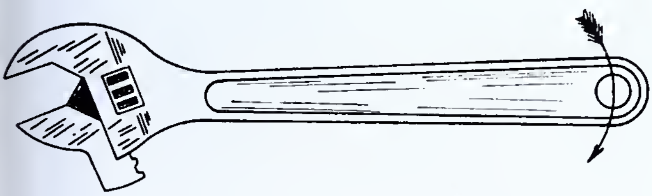


Fig. 40 — *Adjustable Wrench*

Never use an adjustable wrench as a hammer. Keep the adjusting screw (headless machine screw) tight at all times. The screw has a tendency to work loose and when it does, there is nothing to retain the adjusting nut. The result is a useless wrench. The instructor will demonstrate the correct way to use the wrench, point out its ordinary uses, and show how to replace a broken jaw.

Level

The boilermaker uses a level, Fig. 41, on many jobs. Some of the jobs set with a level are: leveling foundations and jacks, setting steel drums and mud drums, fabricating a sea chest, plumbing a boiler wall, etc.

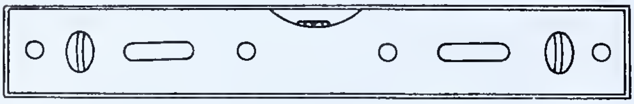


Fig. 41 — *Three-Glass Spirit Level*

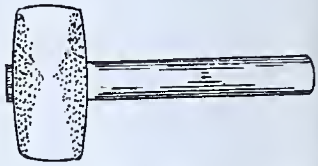


Fig. 42 — *Lead Hammer*

When the bubble is exactly between two hair lines on the glass, the surface upon which the level rests is level. Some levels have three "glasses", and the level may be used to plumb a perpendicular. (The instructor will demonstrate the uses of a level.)

There is a level glass in the square head of a combination square. The head and blade may be used for a plumb, or the head alone may be used for a level on short surfaces of a job. For greater accuracy always use the longest level available. Levels are made from 6″ to 24″ long.

Lead Hammer

A lead hammer (Fig. 42) is used for setting boiler tubes in sheets as the boiler is being assembled. The weight of the hammer makes it possible to strike a heavy blow while using a short stroke. This feature makes it possible to strike a heavy blow in a cramped space where another type of hammer would be useless. The lead will not burr or upset the end of the tube as would be the case with a steel hammer. The lead hammer is safer to use because of the softness of the metal. It will not spall and throw off chips which might cause injuries to hands, face, or eyes.

C Clamps

C clamps, (Fig. 43) sometimes called thumb clamps, are used to hold pieces of plate temporarily in place while the plates are being tack welded. Always use a clamp that is large enough for the job. To strain a clamp by forcing it and destroying its shape makes it useless for the work for which it is intended. Pounding or hammering on a C clamp is not permissible. Never use a wrench for tightening the clamp. Use the wing end of the screw to tighten and loosen the clamp. C clamps also are used to hold a straightedge on a foundation while locating a point with a plumb bob and line.

Hand Spring-Clamp

The hand spring-clamp shown in Fig. 44 is used to fasten templates temporarily to the work while marking the lines. The clamps also may be used to hold a steel tape in position around a cylindrical or curved surface. Many other similar uses may be found for them.

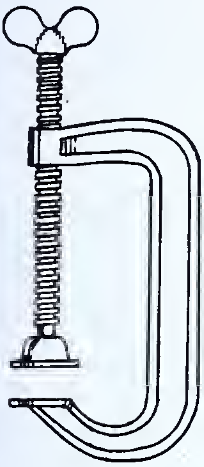


FIG. 43 — *C Clamp*

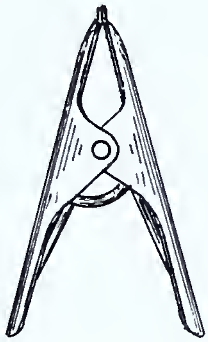


FIG. 44 — *Hand Spring-Clamp*

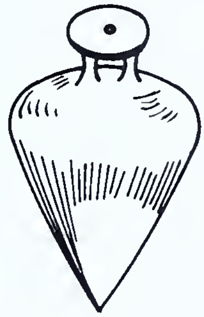


FIG. 45 — *Plumb Bob*

PLUMB BOB AND LINE

In long, vertical distances where a point several feet below must be lined up with a fixed point above, a level cannot be used to advantage. In this case use a long chalk line, which is a heavy cord with a weight on the bottom end to hold the line taut. See Fig. 45. The weight is called a "bob", and the line is then known as a "plumb line". As the illustration shows, the plumb bob is pear-shaped with the small end hanging down. The small end is pointed. There must be no "swing" when the line is in use; otherwise inaccuracies will result.

The point of the plumb bob will hang directly over the location when the upper end of the line is held on the mark at the top. A location at the top of the work may be laid off from a point below by means of a bob, but it is customary to work from the top down. After the line has been located, it is possible to take measurements, using the plumb line as a center line and measuring off in any direction at right angles to the plumb line. (The instructor will demonstrate the use of a plumb bob and line.)

DRIFTS

When two overlapping plate edges have holes for bolts or rivets, the holes are faired by sticking a drift through two of them that match correctly and working the drift sidewise until all the holes are drawn into line so that a rivet or bolt can be pushed through properly matched adjoining holes.

FIG. 46 — *Drift*

There are many sizes and lengths of drifts. See Fig. 46. A drift may be used to guide a boiler or plate to the exact location by slipping the drift through a hole in one piece and inserting the drift point into the correct hole in the other piece.

Socket Wrench

These wrenches are sometimes made in the shop by cutting off a piece of pipe and forming one end to fit a hexagon nut. Holes are drilled through the other end for the insertion of a rod to be used as a handle. See Fig. 47. The length of the socket wrench makes it possible to reach into deep places not easily accessible with another type of wrench. While these wrenches are very useful, they will not withstand so heavy a strain as forged socket wrenches.

This end of the pipe has been heated and formed to shape over a piece of hexagon stock of the correct size.

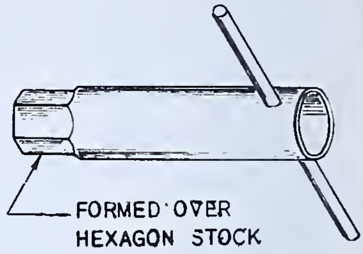


Fig. 47 — *Socket Wrench*

Hack Saws

Hack-saw frames are made adjustable to take blades 8, 10, 12, and 14 inches long. See Fig. 48. A 12″ saw blade is usually a convenient length for ordinary use. The teeth are spaced either fine or coarse and are designated according to the number of teeth per inch.

Note: Some hack-saw handles are made with a "pistol grip".

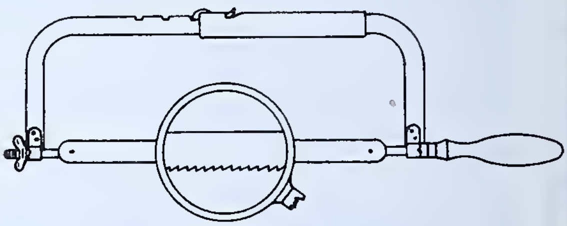


Fig. 48 — *Hack Saw*

Hack Sawing

1. Keep the blade under the correct tension. To avoid breaking blades in your first use of the hack saw, ask the leader for assistance. He will, if necessary, help to adjust the tension.
2. Hold the saw straight across the work, and make even strokes from toe to heel. (The instructor will demonstrate this.)
3. Do not saw too fast. Too much speed can result in "stripping" of the teeth.
4. Do not bear down too much. Too much pressure will "strip" the teeth or "bow" the blade until it breaks.
5. Ease up slightly on the return stroke. The work is done on the "push" stroke.
6. When sawing thin stock or tubing, use a fine-toothed saw.
7. Coarse-toothed saws are better for soft stock or wide material. Fine-toothed saws plug up in soft materials.
8. Do not allow the saw to "bind" in the cut. Follow a vertical line when sawing downward. If the saw is not held "easy" in the cut, the blade is easily broken.

These are only a few of the many precautions to observe when using a hack saw.

Tin Snips

This is really a sheet-metal worker's tool, but it is very useful on many layout jobs.

Some of the principal uses for tin snips are: cutting gasket materials, sheet-metal templates, template paper, soft wire, copper screening, etc. The cutting edges are hardened. See Fig. 49. Never cut hard wire, large nails, or small rods, as the cutting edges are not designed for such heavy work.

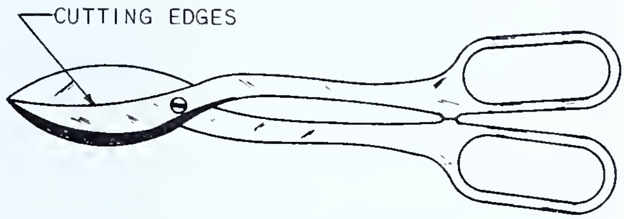


Fig. 49 — *Tin Snips*

Another type of tin snips is shown in Fig. 50. These snips are called AVIATION SHEET-METAL SNIPS and are used for cutting thin sheet-metal templates. The shape of the cutting jaws allows extremely small inside circles to be cut out.

Aviation Snips

The tool shown in Fig. 50 is used for cutting light sheet metal or template paper. The shape and size of the jaws make it possible to cut around inside corners and small-hole diameters. The hook shown at *a* is snapped over pin *c* when the snips are not in use. Rubber grips, shown at *b*, are pulled over the steel snip handles and help to keep the hand from slipping. The rubber also acts as a cushion for the fingers and prevents fatigue.

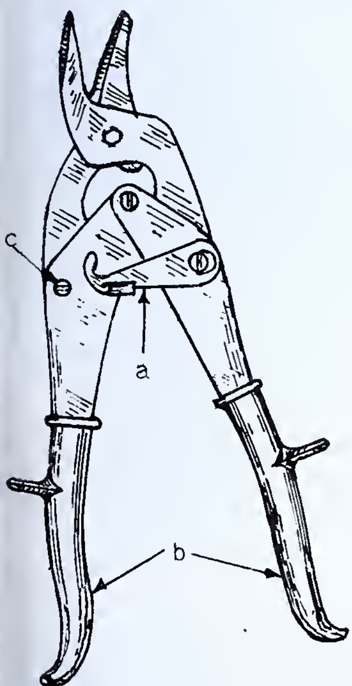


Fig. 50 — *Aviation Snips*

Scriber

Tool steel is necessary for the manufacture of a good scriber. See Fig. 51. The point must be kept sharp at all times. Using the scriber is like using a pencil.

Fig. 51 — *Tool-Steel Scriber*

The difference is that a scriber will make a fine line, no larger than a hair. A dull scriber is worse than none. Close work can be done only when a sharp scriber is used to do the marking. The scriber point is sharpened on an oilstone. Never use an emery wheel. (The instructor will demonstrate some of the uses of a scriber.) Some scribers have a loop in the end as shown; the loop is convenient for hanging up the scriber when it is not in use.

Chalk Line

Fig. 52 — *Striking a Chalk Line*

A chalk line is a heavy, woven-cotton cord. Keep the chalk line in the tool box when not in use. A chalk line is used to "snap" lines on decks or bulkheads. In using the line, chalk it well, stretch it taut between the given points through which a line is to be drawn, and then pick it up about midway between the two points and let go sharply. The line will snap to the original position and make a chalked line on the surface of the work.

Striking a Chalk Line

When a long line must be snapped on the work, it may be difficult to pick up the chalk line and snap it hard enough to make the line show for the full length. A square can be useful, as shown in Fig. 52. The square is placed so as barely to touch the line when it is held taut through the locating points. As the line is picked up, the blade of the square acts as a guide in raising it vertically. Snapping the line can be repeated as often as required to make the chalk line on the work stand out clearly.

The square can be positioned at several intervals when an exceptionally long chalk line is used, and the line may be picked up and snapped at these intervals to make a clear, continuous line.

Two-Foot Steel Square

The ordinary steel square, commonly known as the carpenter's square (Fig. 53) is used by the layout man. Various sizes of steel squares may be obtained, but the most convenient size is a 24″ steel square. The blade is 24″ long, and the tongue is 18″ long. Other sizes are made in the same proportions. The steel square is used to make lines at right angles to each other when the length of lines does not exceed the length of the blade. The square can also be used to square pieces of work. Dropping the square is likely to destroy its accuracy. Handle it carefully.

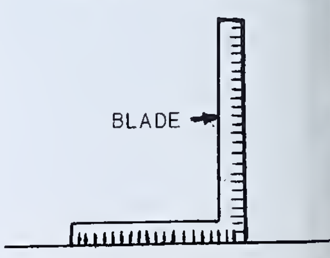


Fig. 53 — *Steel Square*

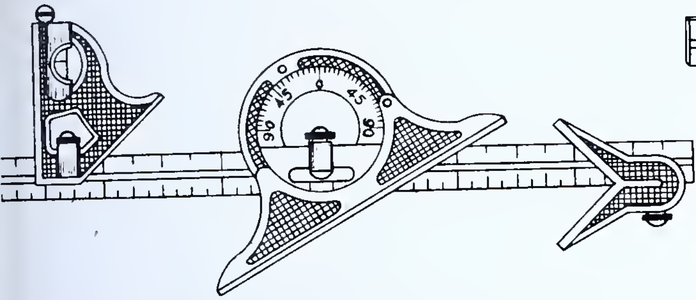


FIG. 54 — *Complete Combination Square*

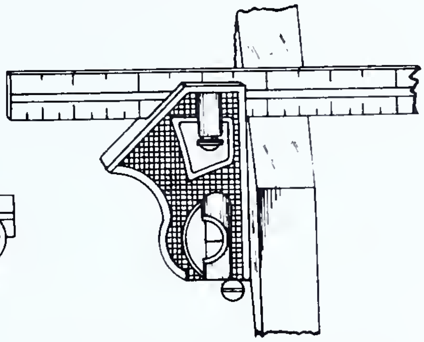


FIG. 55 — *Squaring an Edge*

COMBINATION SQUARE

Figure 54 shows a tool which consists of four parts. The square head, Fig. 55, may be used with the blade to scribe lines at right angles with an edge or surface. When the blade is used with the protractor head, Fig. 56, lines may be laid off from a straight edge or surface at any angle up to 180 degrees. When the blade is used with the center head, Fig. 57, a line may be scribed exactly across the center of a piece of round stock like a shaft end.

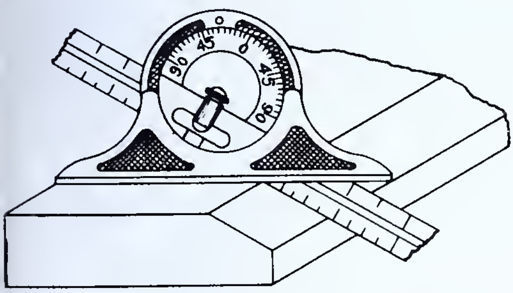


FIG. 56 — *Checking an Angle*

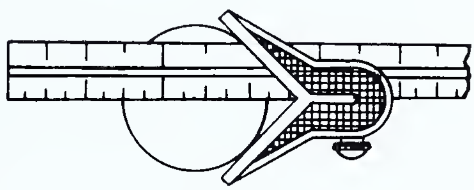


FIG. 57 — *Finding the Center*

The blade is a scale which may be used for measuring just as one uses any other scale. The size of the combination square depends on the length of the blade. The heads of the tool are made in proportion to the length of the blade. Combination sets usually have a 12″ or an 18″ blade. Do not drop the tool, for a fall or a blow

FIG. 58 — *Wooden Straightedge*

will destroy its accuracy. Figure 55 shows that the square head is equipped with a spirit level. The head can be used as a level on short work, or the head and scale can be used to plumb short pieces of work when the mechanic is doing tack welding, etc.

FIG. 59 — *Steel Straightedge — Beveled Edge*

Straightedge

Two types of straightedge are generally used by the layout man in the boiler shop. One type is made of wood, and the other is made of metal.

The wooden straightedge shown in Fig. 58 is planed straight on the long edge. It is used for plumbing a line with some part of the work, for extending a line that has been previously made on a surface, and for testing surfaces to see if they are level.

The metal straightedge shown in Fig. 54 is not so wide as a wooden straightedge. It is generally made by planing the edge of a steel bar to a ¼″ bevel and to about a 1/16″ thickness on the edge. It is used for scribing straight lines and for testing surfaces for evenness.

Angle Gauge

The angle gauge shown in Fig. 60 is used for marking lines around the circumference of a disc or cylinder. The gauge is set to the desired distance which the line is to be from the edge of the circumference, and the tool is then moved a little at a time around the circumference. A mark is made at the end of the slide each time the gauge is moved. The series of marks forms a smaller circle, the circumference of which is parallel to the edge of the work.

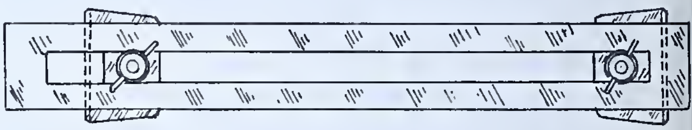


Fig. 60 — *Angle Gauge*

Both ends of the gauge may be set, thus making it possible to mark two parallel lines around a circumference, one at a time.

Drills and Drilling

The boilermaker drills many holes through steel plates, foundations, angles, etc. Twist drills are kept in the tool crib for the purpose of filling the mechanic's needs. As these tools are made of high-carbon or high-speed steel, they may be easily broken. Either the cutting edges may be chipped or the drill may be snapped off short, if the workman does not take care to hold the drill steady while drilling.

Drill Feeds

The action of forcing the drill into the work is called the "feed". Too much force applied to the feed, especially with the smaller-sized drills, will very likely break the drill.

When drilling at an angle, feed very slowly until the drill is cutting "to size". This means until the drill has entered far enough for all of the drill point to be below the surface of the work. Then the drill cannot slip, but it can be leaned sidewise, cramped, and broken. Be careful to avoid breaking the drill.

Types of Drills

Up to 3/16″ in diameter the drill shank is straight. See Fig. 61. A few drills above 3/16″ may be straight, but they are usually tapered. Taper-shank drills hold

better in the drill chuck without slipping than do straight-shank drills. See Fig. 63 and Fig. 65.

Taper shanks are not all the same size. Larger drills have larger shanks, and provision must be made for the drills to fit the drill chuck. All taper-shank drills are usable in one drill chuck by employing taper sleeves in the chuck. The sleeve has a tapered hole which fits the drill-shank taper, and the outside of the sleeve fits the hole in the drill chuck. Both sleeve and drill must be securely inserted to prevent slipping. See Fig. 66.

Flat-Side Tapers

Most shipyard air drilling machines have a flat side in the chuck taper. There is a corresponding flat side on the taper shank of the drill. There is very little danger that this type of drill will slip in a chuck. See Figs. 66, 67, and 68.

Caution

Wipe the hole in the chuck and the shank of the drill with a rag or some clean waste before inserting the drill in the chuck. Never allow dirt or grit to remain on these surfaces. The drill will be thrown out of line and the tapers scored.

When removing the drill from the chuck, use a drift made for the purpose. Never strike the drill to loosen it from the chuck or sleeve.

A drift is a piece of steel tapered like a wedge. The drift thickness fits the width of the slot in the chuck spindle or taper sleeve. The thin edge of the wedge is inserted in the slot between the end of the drill shank and the upper end of the slot. As the drift (wedge) is driven inward, it forces the drill downward. A light blow is sufficient in most cases.

Grinding Drills

Always examine drills when getting them out of the tool crib. A dull drill never cuts well and is likely to "burn" (lose its temper) if used. If the drill is dull, have it ground or exchange it for another at once. If by some accident or mishandling the drill is broken or chipped while in use, have it replaced or ground immediately. Do not risk spoiling a job by trying to use a faulty tool. When applying at the tool-crib window for drills, be sure the tool-crib attendant furnishes the drill sizes requested.

Lubrication

When one drills cast iron no lubricant is necessary. Use a light lubricant for steel. The lubricant acts as a coolant and prevents the drill from burning. Sometimes a hard spot is encountered in the metal. Continuous drilling on such a hard spot may ruin the drill point. The addition of lubricant will not help the situation in most cases. Use a high-speed drill (this does not mean to run the drill at high speed) or chip the hard particle out with a gouge or diamond-point chisel. If it is found that the metal is hard, stop at once. Hardened metal must be annealed before it can be drilled. An application of heat with an acetylene torch may help, but the metal should be covered and allowed to cool slowly before proceeding. In case heat is not

available or a part can not be heated owing to the grade of steel or to other near-by parts being affected by the heat, use a little turpentine and grind the drill often.

When drilling brass use a very light oil or a drilling compound. The cutting lips of the drill must be ground with a neutral rake to prevent "hogging in". Hogging is very likely to occur when following a pilot hole. Be sure the cutting lips of the drill are ground to the same length.

Starting a Large Drill

Drills of 1¼″ diameter and larger do not start very easily in a center-punch mark. The best thing to do in this case is to drill a "pilot hole" first. The size of the pilot hole used is from 3/16″ to ¼″. The point of the drill should clean just a little stock out of the pilot hole as the drilling progresses. See Fig. 64.

There is one thing to watch when drilling the large hole through the pilot hole. The large drill will "hog in" (catch and break) if the feed is not eased up at the finish of the drilling. Go carefully on the first few holes, and experience will show just how much to ease up the pressure towards the end of the drilling.

"Drawing" a Drill

When drilling a hole without using a pilot hole, the drill may "run off". See Fig. 62. The operator should raise the drill from the work to inspect the cutting location before the drill has gone in far enough to cut to size. If the hole shows signs of running off, chip a groove with a gouge chisel on the wide side of the layout. See Fig. 62. This groove will cause the drill to "bite in" each time the cutting edge hits the groove. If the drill is still off after a few more turns, chip the groove again until the drill is cutting central with the layout. The instructor will demonstrate the correct procedure.

When one drills a hole following a pilot hole, the drill cannot be drawn over. This means that extra care must be used when drilling the pilot hole.

Drill Sizes

Ordinarily, drill sizes are stamped on the shank in fractions of an inch. Nearly all drills used by the boilermaker are stamped. For example: ¼″; 21/32″; 1⅛″; 1-3/16″ and many others.

Cutting Speeds of Drills

Circumstances control the cutting speed of drills in most cases. Small drills run much faster than the larger drills. This is a matter for good judgment. A good rule to follow is:

70′ per minute for cast iron

35′ per minute for steel

200′ per minute for brass

Note: The speed of a drill is based on the number of revolutions it makes per minute.

If it is found that the drill will cut well, hold its edge, and do a good job at a higher rate of speed, step up the speed.

Tighten a straight-shank drill securely in the chuck to prevent scoring the body of the drill shank.

Fig. 61

The hole should go through here.

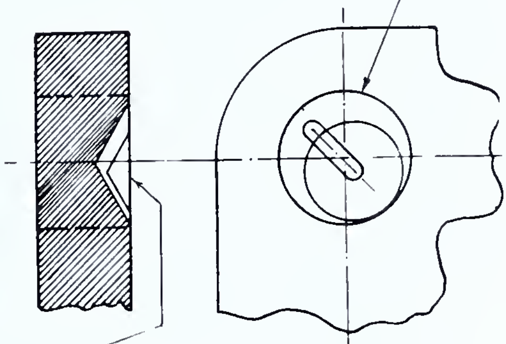


Fig. 62

The drill has started to run off here.

"Draw" the drill back "to center" by chipping as shown. Use a gouge chisel to chip the groove.

Fig. 63

Flat side on taper-shank drill prevents turning in the chuck. Taper shank holds drill in chuck without tightening.

Taper Sleeve

Fig. 65

Used in drill chucks to hold drills that are smaller than the chuck size.

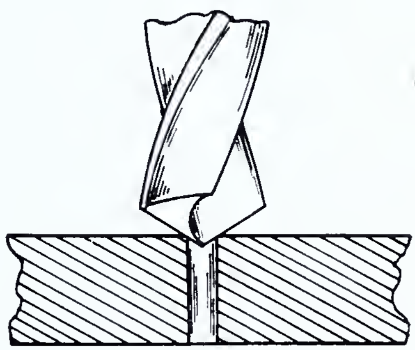


Fig. 64

Following a pilot hole, the drill has no chance to run off. Be sure the pilot hole is correctly centered before starting the large drill.

FIGS. 61-65

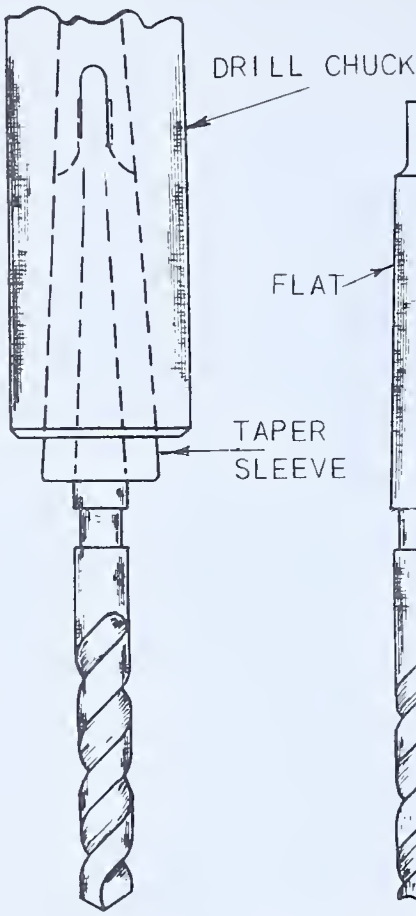
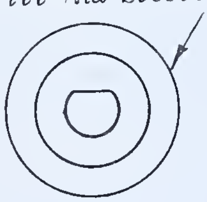


Fig. 66

Top View Of Chuck, Drill And Sleeve



The taper sleeve is used to make up for the difference between the size of the hole in the chuck and the taper shank of a small drill.

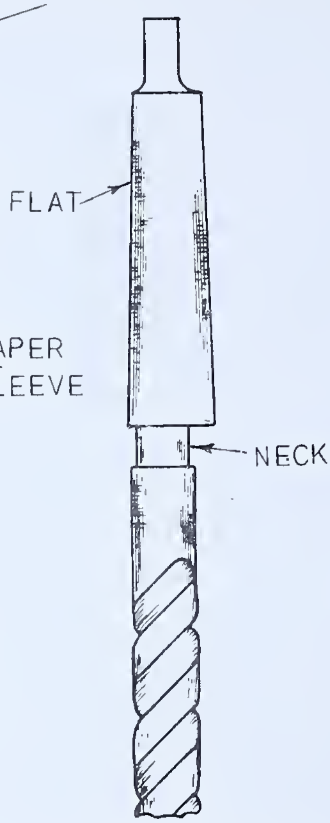


Fig. 67

Showing a taper-shank drill with the shank larger than the drill.

Care must be taken not to apply too much pressure and snap the drill at the neck.

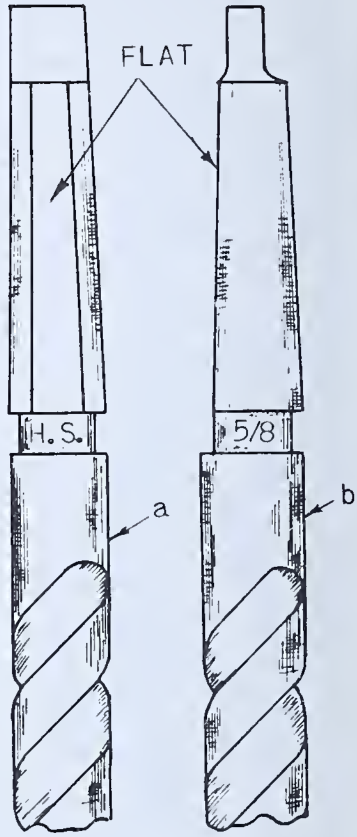
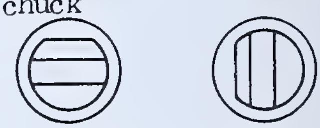


Fig. 68

Two views of taper-shank twist drill with a "flat" to prevent turning in the chuck



Top Views Of Taper-Shank Drill

Figs. 66-68

It is better to run a drill slowly and step up the speed rather than to begin at high speed and possibly burn the drill. Check with the instructor or leader.

Enlarging Holes Already Drilled

Consider a 1″ hole drilled through a hub or a thick plate. Perhaps it is necessary to enlarge the hole ¼″. The drill will have a tendency to "hog in" when starting the larger drill in the hole. Run the drill slowly and feed lightly. The drill will hog into steel or brass more than it will into cast iron. It may be necessary to grind the "rake" off the cutting lips of the drill. Check with the leader in such cases.

QUESTIONS

1. **What is understood by a "drill feed"?**
2. **Explain the difference between a straight shank and a taper shank.**
3. **Why are the taper-shank drills "flatted" on one side?**
4. **What is the correct method of removing a drill from the chuck or sleeve?**
5. **Explain what is meant by "burning" a drill. What causes it?**
6. **When is a lubricant on a drill necessary?**
7. **Explain the action of a lubricant.**
8. **What is meant by a "pilot hole"?**
9. **Explain the necessity for a pilot hole.**
10. **State precautions necessary when following a pilot hole.**
11. **What is understood by the statement: The drill may "run off"?**
12. **How is a drill "drawn" back to center?**
13. **Name two ways to check the size of a drill.**
14. **Is the cutting speed for brass different from that for cast iron? How much different?**
15. **What is the correct procedure when a drill-cutting lip breaks off? State the probable cause.**
16. **What is a "drift" when mentioned in connection with drilling?**

TOOLS (*Continued*)

Pneumatic Wire Brush

The pneumatic wire brush (Fig. 69) is used to remove rust and accumulations from the ends of boiler tubes before they are installed. The pneumatic wire brush is also used to clean welds.

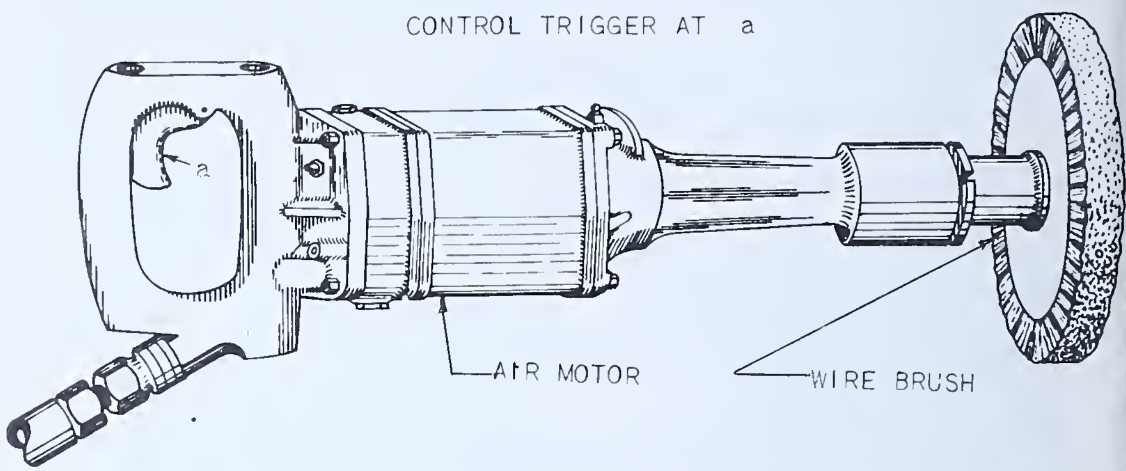


Fig. 69 — *Pneumatic Wire Brush*

Pneumatic (Air) Portable Grinder

A portable grinder (Fig. 70) is used, wherever possible, to expedite the work of the boiler maker. Uneven surfaces, rough edges on plates, excess stock on the inside diameters of holes, rough spots or burrs may be ground smooth with the pneumatic portable grinder.

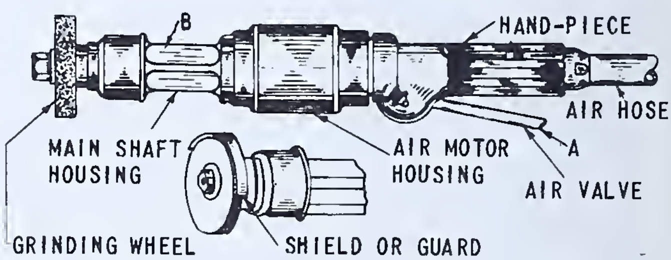


Fig. 70 — *Portable Grinder*

The Air Motor

The portable grinder is driven by an air motor which receives a steady supply of compressed air through a heavy rubber hose attached to the hand piece of the grinder.

Figure 70 shows an air valve at *a*. The position of the air control makes it easy for the operator, by a slight pressure of the hand to admit or cut off the air instantly.

Operating the Grinder

When grinding, the operator must keep his hand on the air control constantly; for when the valve is released, the wheels stop. The other hand is placed to grasp the neck between the grinding wheel and the motor housing at *b* to guide the machine

over the work. After a little practice the operator will discover the correct way to stand to hold a balance and guide the grinding wheel.

In using the grinder, the operator does not need to "lay on" the machine to make it grind. If too much weight is applied, the wheel will slow down and consequently less work will be accomplished. A steady, even pressure while the machine is kept moving slowly back and forth will remove stock quickly and do a smooth job.

Grinding Wheels

The grinding wheels used are about 1¼″ to 1½″ thick and 4″ to 8″ in diameter. Be careful to use a wheel of the correct grade and grit for the job. The grade of wheel used for steel is not generally used for cast iron. Check with the leader about the correct grade of wheel to use.

Clearing the Line

Before attaching the air hose, clear the line by turning on the air at the main valve. This will blow out any dirt or water that may have collected in the line. If the motor slows up or sticks, the application of a little light machine oil will clear the valve..

Disconnect the air hose from hand piece, pour a little light oil in the connection, replace the air hose and start the motor.

Safety Precautions

When the grinder is laid down, never move the air control valve. To do so may cause the machine to roll around and possibly drop to the floor which could result in serious injuries.

Never hook up a portable grinder and then raise or lower it by means of the air hose. The coupling could let go or the air hose might break; either could have serious results. Never remove the guard over the grinding wheel except when grinding the internal diameters of holes that are too small to accommodate the guard.

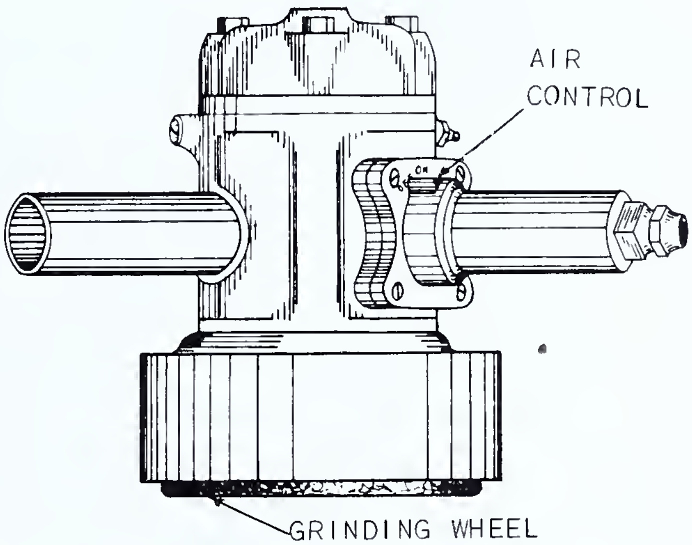


Fig. 71 — *Pneumatic Surface Grinder*

Making Repairs

Never attempt to take a portable grinder apart if it seems to need repairing. Such work is always done in the tool room by experts. Report to the leader at once if the machine fails to work properly.

Pneumatic Surface Grinder

The pneumatic surface grinder (Fig. 71) is mostly used when removing uneven spots or burrs from a horizontal surface. The grinder is held in both hands and

moved about as the grinding progresses. The hand on the air control side must always be kept in readiness to manipulate the control valve should it become necessary to stop the machine quickly.

The same rules for using the pneumatic surface grinder and the same safety precautions apply that are outlined in the use of a pneumatic portable grinder.

QUESTIONS

1. **Name a few jobs where a portable grinder is used.**
2. **In what way does a pneumatic surface grinder differ from a pneumatic portable grinder?**
3. **How is the action of the air motor controlled?**
4. **Explain the correct method of grinding with a pneumatic surface grinder.**
5. **Where does the operator place his hands when he is using a portable grinder?**
6. **Explain how the line is cleared before the air hose is attached.**
7. **Who makes the decision regarding the correct type of grinding wheel to use for the job?**
8. **Explain how the operator can control the grinder to make it work best.**
9. **Name a few safety precautions which should be observed when using either a pneumatic portable grinder or a pneumatic surface grinder.**
10. **What should be done when it seems that grinders need repairing?**

TOOLS (*Continued*)

Pneumatic Air Hammer

The pneumatic hammer, Fig. 72, is equipped with a nose which looks like a drilling machine chuck. A round socket is provided in the nose of the hammer to receive the round shank of any of the chisels or calking tools described under the headings.

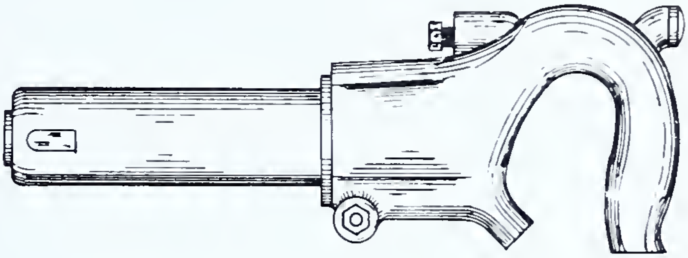


Fig. 72 — *Pneumatic Air Hammer*

The hammer is operated by an air trigger which is quite close to the thumb when the hand grips the handle. Never start the hammer in action until the chisel or other tool is grasped with the left hand at the same time it is held against the work.

Safety Precautions

Never attempt to force a chisel shank into a hammer socket. Never use a small shank in a socket. It is unsafe practice to do so and the socket and shank will be injured by these misfits.

Never lay down a hammer without removing the chisel or other tool. An accidental contact with the trigger which operates the hammer will cause the chisel or other tool to leave the socket like a gun-shot. Serious injury could be caused by such carelessness.

Pneumatic (Air) Drilling Machine

The drilling machine shown in Fig. 73 is air driven. The handwheel shown at *a* is on the end of a feed screw. Turning the hand wheel clockwise "feeds" the twist drill into the work. The machine can be held at an angle, in a horizontal position, or vertically as shown in the sketch.

When drilling some jobs it is possible to do the work faster if a "drilling stick" is used to apply the feed as shown in Fig. 74. In this way the operator can control the position of the drilling machine and apply the feed without the aid of a helper.

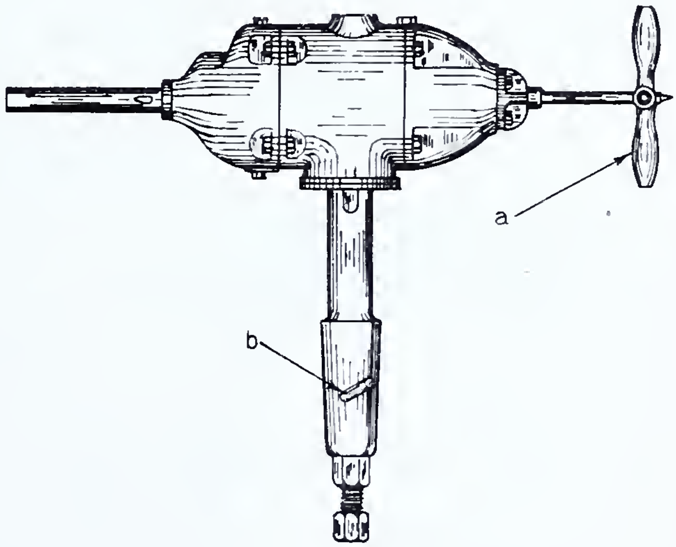


Fig. 73 — *Pneumatic Drilling Machine*

The air control for the machine shown in Fig. 73 is at *b*. A slight turn of the wrist admits or cuts off the air by means of the valve inside of the sleeve.

The air control for the machine shown in Fig. 74 is at *c*. It also is operated by a turn of the wrist.

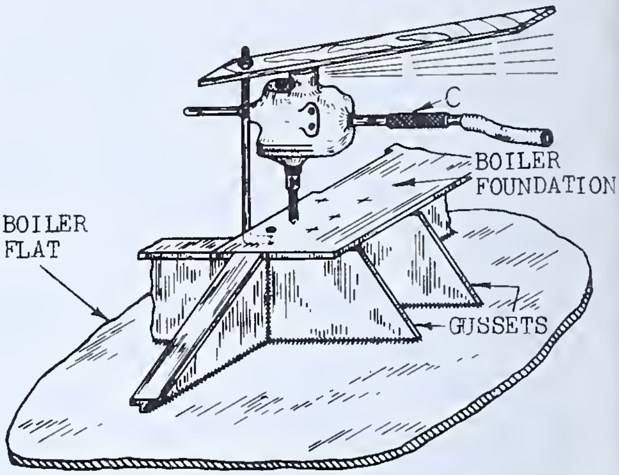


Fig. 74 — *Using a Drilling Stick*

For small holes a pistol-grip air drill is used. See Fig. 75. It can be used in limited spaces. This tool is convenient for drilling holes close together and for drilling after a job has been assembled.

These drilling machines can be overloaded and drills can be broken if the operator does not hold steadily. Always be certain of good footing. Handle the drills and the taper sleeves carefully to avoid causing small nicks and pimples on the drill shanks or sleeves. Defects such as these will cause the drills to slip and they will not run true. Always use a drift, where one is provided, to remove a twist drill from a chuck.

Cutting Chisels

During the construction and the erection operations inside and outside of the boiler shop much cutting and chipping of metal must be done with a chisel. Since the work to be done is generally heavy and often continuous over a period of hours it is not done by hand. A pneumatic hammer

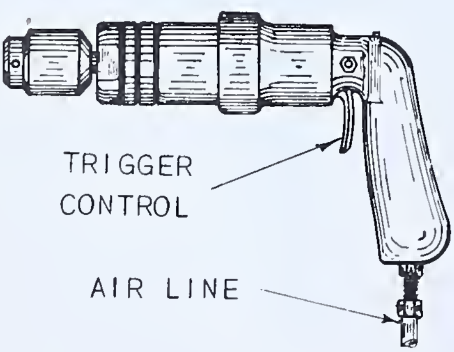


Fig. 75 — *Pistol-Grip Air Drill*

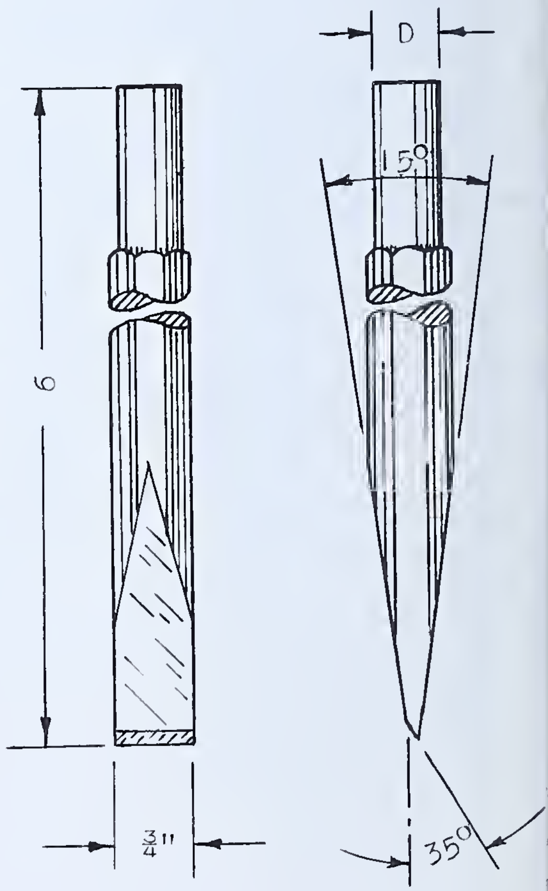


Fig. 76 — *Flat Chisel of Side Cutting Chisel*

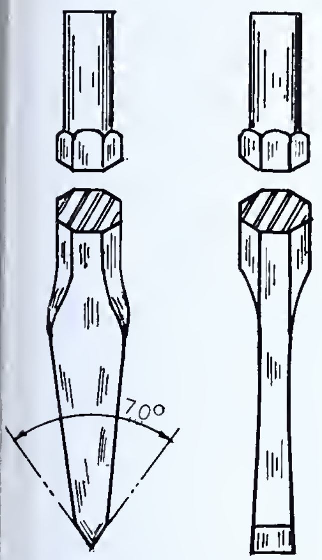


FIG. 77 — *Cape Chisel*

(Fig. 72) which is equipped with an air trigger and a socket for holding the chisel, is used to do all such cutting and chipping jobs.

Chisel Shanks

The shanks on all cutting chisels fit the socket in the pneumatic hammer. Do not use a small shank in a large hammer socket. Avoid causing burrs on the chisel shanks which will result in poor fits in the hammer socket.

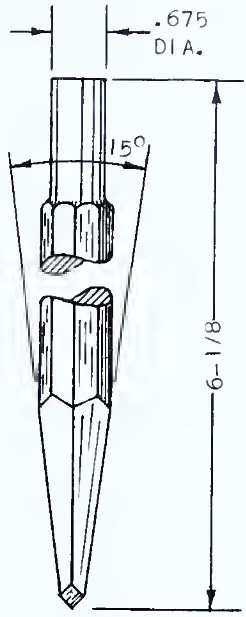


FIG. 78 — *Diamond Point Chisel*

Cutting Edges

The cutting edges are of various shapes and each shape has some specific use. They must be kept sharp for doing the best work. It is dangerous to use dull chisels.

The most simple form of metal cutting tool is the chisel. With a little practice it is possible to cut a line either straight or curved. The flat chisel, Fig. 76, is used for chipping burrs and rough spots from surfaces, for trimming the edges of plates, and for all general chipping operations. In the boiler shop it is called a side cutting chisel.

Special Purpose Chisels

The cape chisel, Fig. 77, is used for cutting keyways, narrow channels, and for cutting a series of grooves across surfaces which are to be leveled off later with the flat chisel. The raised portions of the original surface are called "lands". The flat chisel is allowed to rest on the bottoms of the grooves previously cut with the cape chisel and thus the entire surface is roughly leveled.

The diamond point chisel, Fig. 78, is used for drawing the outlines of markers, lettering, stack insignia, and for cutting holes in flat plates with the aid of the chisel called the ripper.

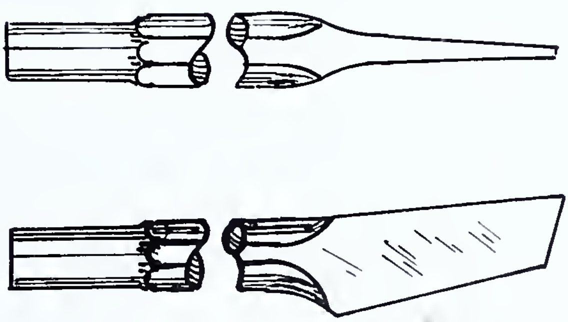


FIG. 79 — *Ripper Chisel*

The ripper chisel, Fig. 79, is used to follow the diamond point chisel for cutting holes in flat plates. The chisel

is very thin edgewise and this feature in addition to the "rake" on the width of the tool helps the chisel cut quickly through a fairly heavy plate.

The gouge or round nose chisel is round in the section near the cutting end. Figure 80 shows two views of a gouge chisel. The cutting edge is ground at an angle of 60° with the axis of the chisel. This type of gouge chisel is used in the starting cut of drilled holes to bring them concentric with the drilling circle.

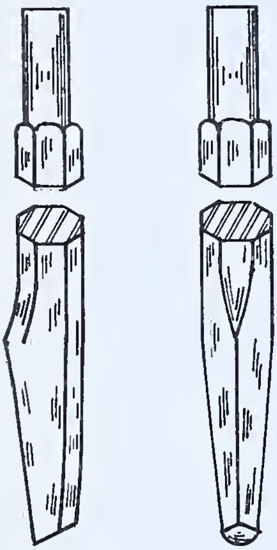


FIG. 80 — *Gouge or Round Nose Chisel*

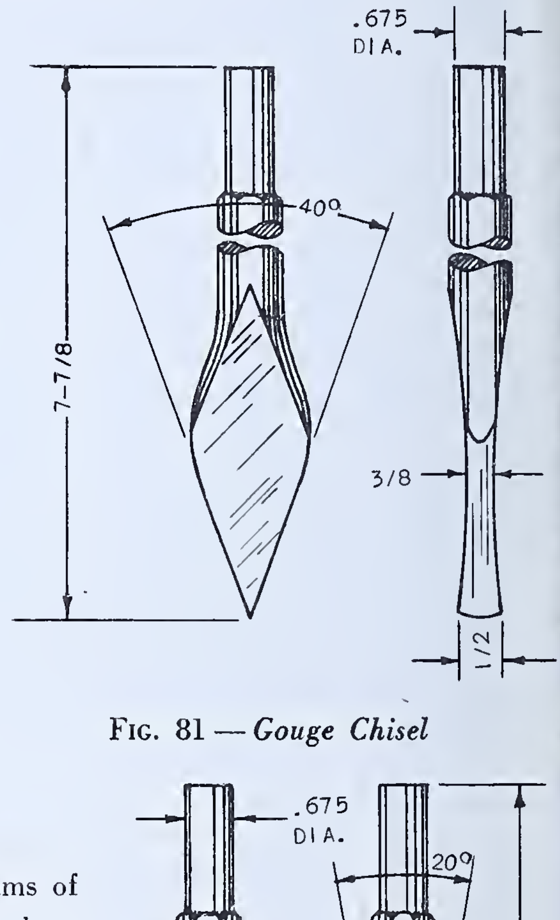


FIG. 81 — *Gouge Chisel*

It is also used to chip grooves in the seams of welded plates, and for chipping deep, narrow channels in pipe, plate, and castings where small cuts are required. The gouge or round nose chisel also is used to prepare the edges of plates, holes and reinforcement plates for U welding.

Another type of gouge chisel is shown in Fig. 81. It is used for roughing off beads, for chipping bevels on the edges of plates, for burring or beveling the edge of a plate around a hole, etc. This type gouge chisel is most often used in connection with the work of boiler erection.

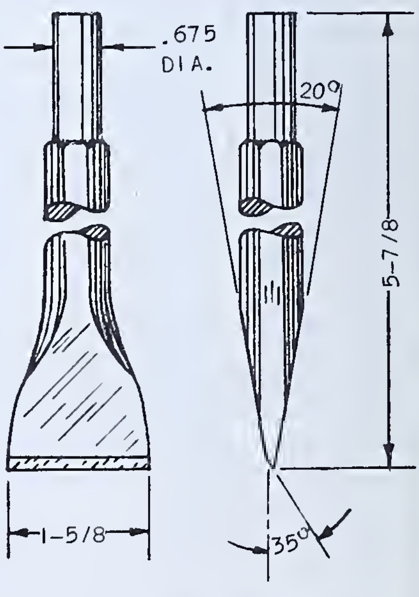


FIG. 82 — *Hot Rivet Chisel*

The hot rivet chisel is shown in Fig. 82. Note the extra width of the cutting edge and the manner in which it is ground. This type chisel is used for cutting off level the point of the rivet after it has been riveted over hot. The bevel on only one side makes it possible to cut off smoothly to the plate, the projecting end of the rivet. This type chisel is mostly used in connection with the work of erecting stacks, fabricating deck sections, etc.

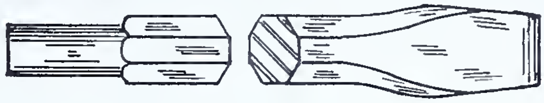


FIG. 83 — *Bent Calking Tool*

CALKING TOOLS

After plates are riveted together the overlapping edges of the plate are calked as shown at *a*, Fig. 84. Note how the edge of the plate has been upset to form a tight joint with the under plate. The calking is done with a round nose tool and a pneumatic hammer. Calking is never done until after the riveting is completed. The calking tool shown has a bent nose to allow it to be used in close proximity to rivet heads, etc. Forcing the metal in close contact with the lower plate makes the joint steam-tight. A tool with a sharp edge must never be used since it will score the under plate and cause grooving.

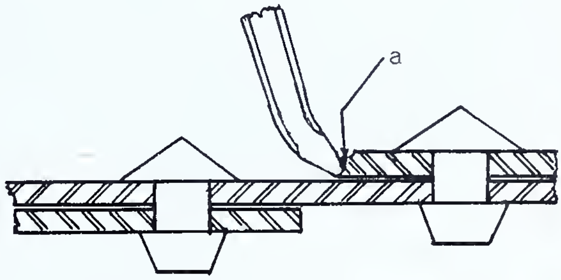


FIG. 84 — *Bent Round Nose Tool*

The rough bobbing tool shown in Fig. 85 is used for upsetting a rivet head after it has been installed as tightly as possible with a rivet gun. The use of the bobbing tool is shown in Fig. 86. The edge, if forced in close contact with the plate and the joint is thus made steam or liquid tight. The knurled end of the tool helps upset the rivet head to close the joint steam-tight.

The square nose roughing tool is knurled on the point as shown in Fig. 87. It has many uses as a roughing tool. The knurled point aids in quickly upsetting the metal. For example: A bead weld may be tightened or set-in very quickly with the aid of a square nose roughing tool.

FIG. 85 — *Rough Bobbing Tool*

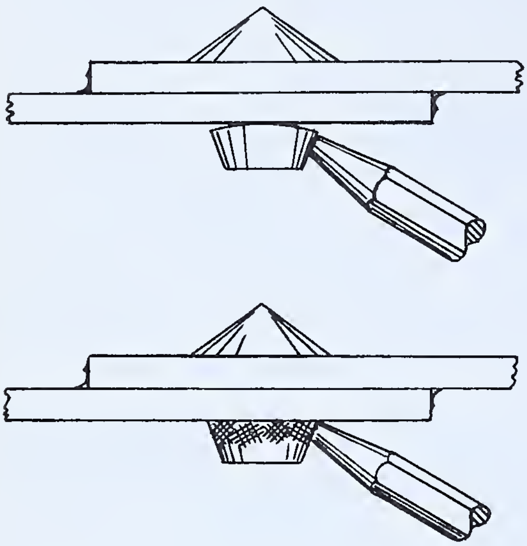


FIG. 86 — *"Bobbing-up" a Rivet*

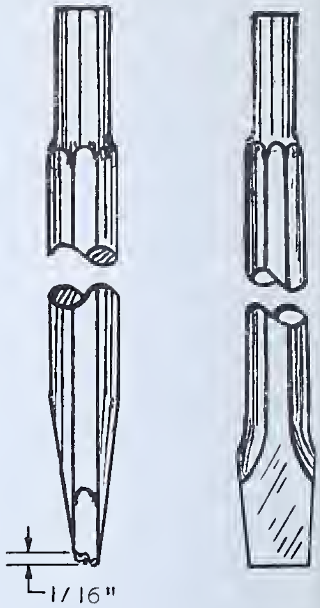


FIG. 87 — *Square Nose Roughing Tool*

The 1/16″ rake on the point of the tool makes it possible to calk the joint tightly because the bevel has a tendency to drive the plate down instead of lifting it up as would be the case with a straight point.

The beading tool shown in Fig. 88 is used to force the expanded end of a boiler tube against the tube sheet as shown in Fig. 89. The "heel" shown at *a*, Fig. 89 must

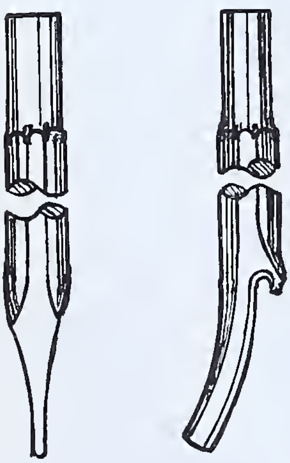


FIG. 88 — *Beading Tool*

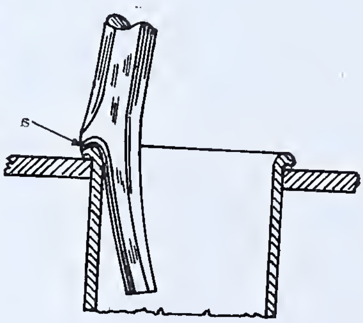


FIG. 89 — *Using the Beading Tool*

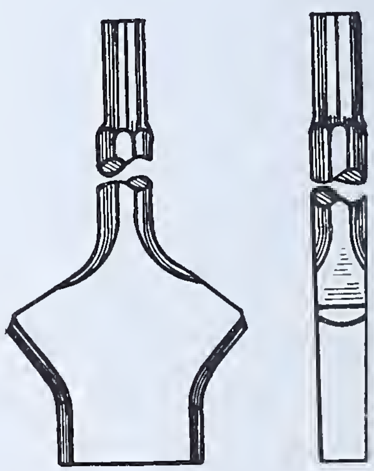


FIG. 90 — *Flaring Tool*

ıot be long enough to strike the tube sheet. Should the heel strike the tube sheet t will be impossible to force the bead down and obtain a steam-tight joint.

The flaring tool shown in Fig. 90 is exceptionally vide and proportionately thin. The sides are rounded o allow the tool to fit easily the inside of a boiler ube. The shank fits the pneumatic hammer so the tool an be used in the same manner as other pneumatic ıammer chisels and calking tools.

The tapered portion of the flattened blade allows it o be used in tubes of different diameters for the pur-›ose of flaring the end of the tube. A flared tube end s shown in Fig. 91.

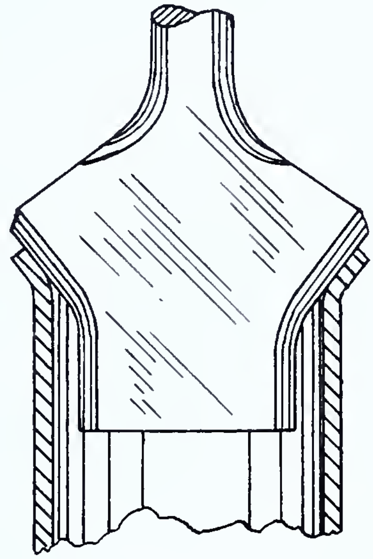


Fig. 91 — *Flaring a Tube End*

'LANGING MAUL

The flanging maul shown in Fig. 92 weighs about 2 pounds. It is used for flanging hot plates but it lso can be used on cold plates. The rounded faces f the maul eliminate the possibility of marking the ork when a heavy blow is struck, or when the blow s struck at an angle.

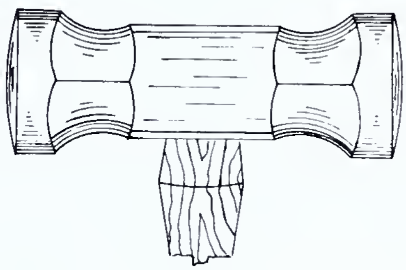


Fig. 92 — *Flanging Maul*

'OP SWEDGE

The top swedge (Fig. 93) is used in much the same ıanner as a flatter but for a different purpose. Its rincipal uses are: straightening stay bars and round-ıg forged work. The radii of top swedges vary from ⁄8″ to 1¼″.

'ACKING OUT PUNCH

The backing out punch (Fig. 94) (sometimes called B and O punch) is used for breaking rivet heads and for driving them out of the hole. It can also be used to punch holes in hot plates. The punch is made in many lengths and diameters to suit various types of work.

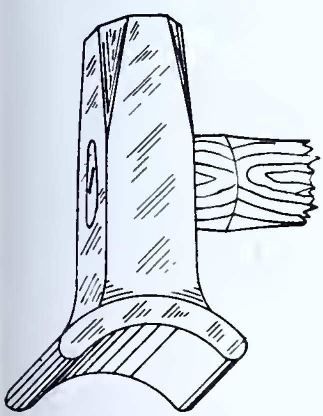


Fig. 93 — *Top Swedge*

WHITNEY PUNCH

The Whitney punch (Fig. 95) is

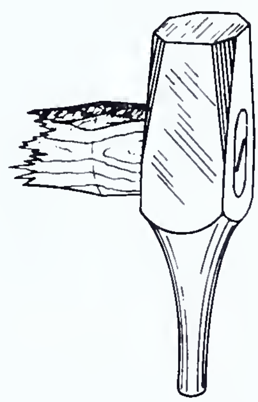


Fig. 94 — *B and O Punch*

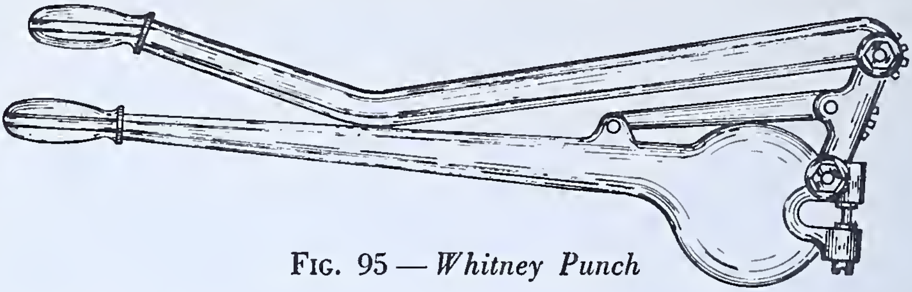


Fig. 95 — *Whitney Punch*

used to punch holes along the edges of sheet metal if the thickness does not exceed 16 gauge. The action is powerful and fast and much time is saved because the metal sheets do not have to be carried around the shop.

Y-Branch Connection

Two lead lines of air hose can be connected to a Y-branch connection (Fig. 96) much the same way in which two electric light cords may be plugged into a two-way socket. The couplings snap into place easily and are air-tight. They let go as readily but the slip-collar must be pushed down and turned when the connection is made or when it is broken.

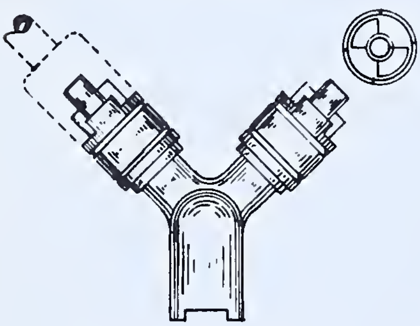


Fig. 96 — *Y-Branch Connection*

Tube Expander

This tool (Fig. 97) is self-feeding and it is used for expanding heavy tubes in heavy tube sheets.

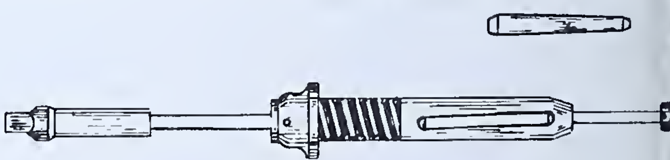


Fig. 97 — *Tube Expander*

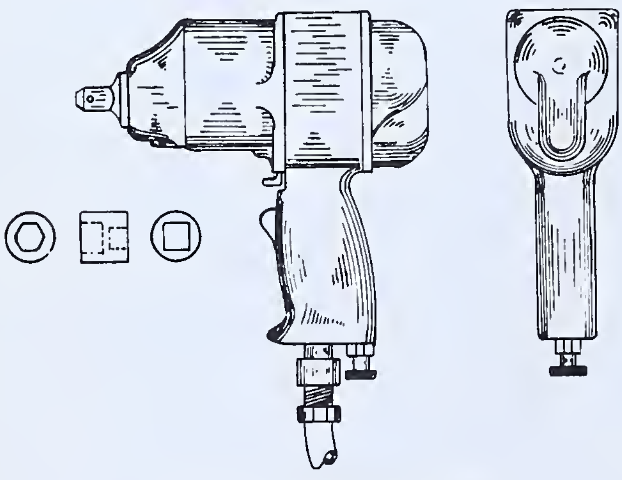


Fig. 98 — *Impact Wrench*

Impact Wrench

This tool is air-operated anc has a capacity sufficient tc tighten a ¾″ nut. The pisto grip, trigger control, and com pact size (Fig. 98) makes i possible to use the tool in clos places. It is often called "knock-knock" because i sounds much like the poundin noise that is made with knocker.

One man can operate it, no open end wrench is necessary, and it is a grea time saver.

Pneumatic "Holder-on"

When riveting in a marine boiler the rivets frequently must be driven or headed from both sides. The tool shown in Fig. 99 is held on the head of the rivet. It runs continuously and is operated by one man. Interchangeable dies are placed in the nose of the tool to form any desired shaped head on the rivet.

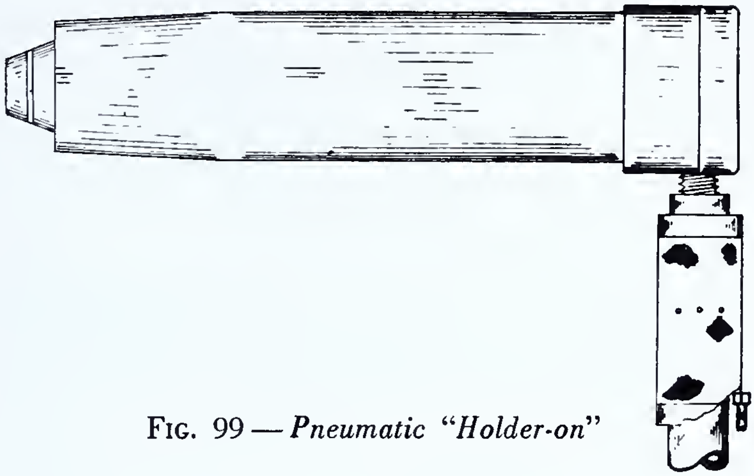


Fig. 99 — *Pneumatic "Holder-on"*

Automatic Plate-Lifting Grab

This devise is used for quickly lifting hot plates with the crane. The teeth in the jaws (Fig. 100) prevent the plate from slipping. The weight of the plate causes the jaws to close and grip or "grab". It is never used to carry plates over workers because while it is a very useful device for turning plates it is not considered to be absolutely safe. Stay away from a position under plates of any description wherever they may be.

Hydrostatic Pressure Recorder

After pressure tanks are completed and after the piping, and other inside work has been installed in the tank it is sealed. All nozzle openings in the

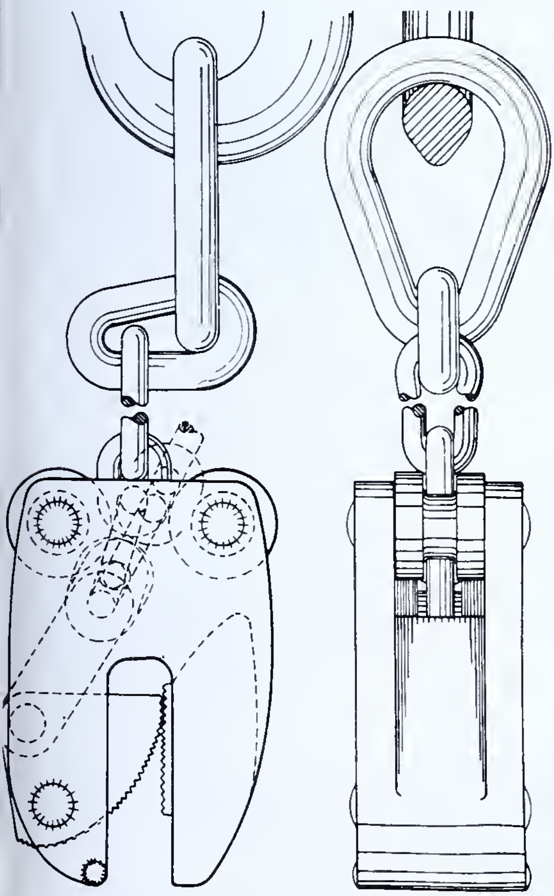


Fig. 100 — *Automatic Plate-Lifting Grab*

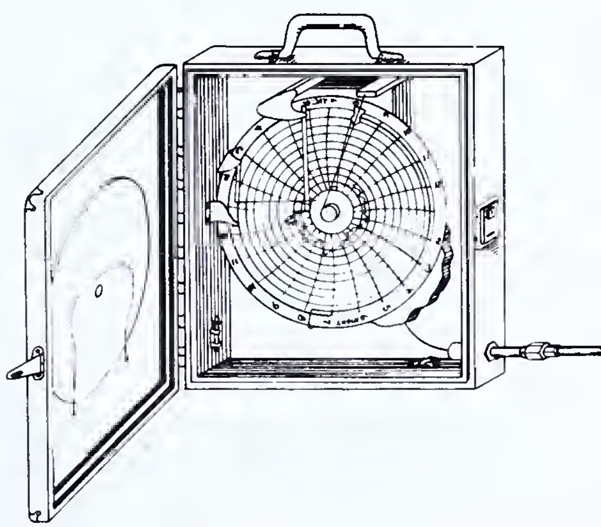


Fig. 101—*Hydrostatic Pressure Recorder*

tank are sealed and the job is tested for leaks and hammer tested for fractures. All vessels of this description are built and tested according to the API (American Petroleum Institute) and must withstand certain pressures before being accepted. The pressure is recorded on the chart (Fig. 101). If the job leaks the recorded line on the chart will be wavy and the falling pressure is automatically registered.

Acetylene Torch

The acetylene torch is a special torch for grooving plates previous to welding (Fig. 102). Note the short curved nozzle which is especially made for this purpose. The torch also is used for cutting out defective welds.

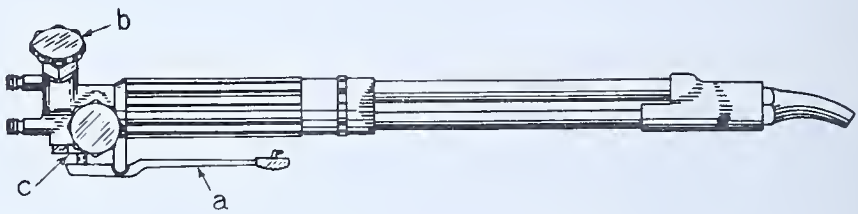


Fig. 102 — *Acetylene Torch*

Portable Rolls

The rollers in a portable roll (Fig. 103) are used in pairs for the purpose of turning round tanks on which welding or chipping operations must be performed. The rolls are heavy enough to have sufficient stability for the job to be done but are light enough to be transported about the shop when necessary.

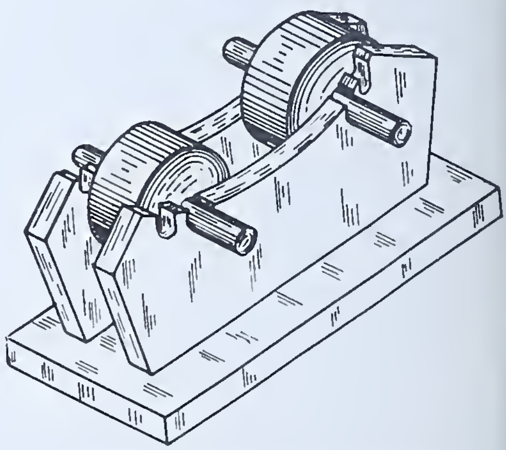


Fig. 103 — *Portable Rolls*

Sootblower Tap

The sootblower tap (Fig. 104) is used for tapping the holes for the air tubes in the back head of the firebox. The sootblower tubes are installed after the air-blower tubes have been tapped. This tap is approximately 3″ in diameter and is operated by an air machine applied to the square shank.

Fig. 104 — *Sootblower Tap*

Special Calipers

The caliper (Fig. 105) is especially made for measuring the thickness of nozzle walls. Ordinary calipers are not suitable for measuring in these places because they have no registering device such as is shown on this special caliper. The thickness of the wall can be read directly on the square without removing the caliper from the nozzle. This type of caliper is very useful in measuring beyond beads or flanges at the ends of the nozzle openings.

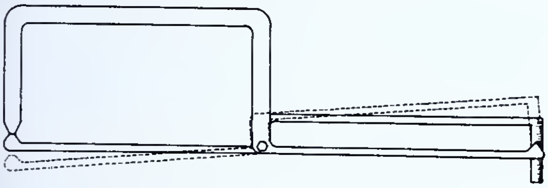


Fig. 105 — *Special Calipers*

Finding the thickness of the metal (Fig. 106) in the dished-head flange is easily accomplished when these special calipers are used.

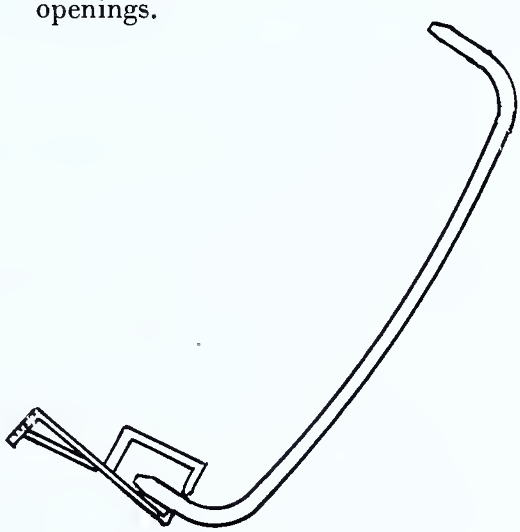


Fig. 106 — *Using Special Calipers*

Soapstone Pencil

This gray mineral received its name from the soapy feeling experienced when it is rubbed between the fingers. It is used wherever temporary markings have to be made. (Fig. 107). It is sturdier than chalk, and the marks made with it are not rubbed off quite so easily as are chalk lines. Because of its flat shape it can be used to good advantage with a straightedge. In work where trammels have to be used, special holders for soapstone make it possible to scribe large circles or arcs.

Fig. 107 — *Soapstone*

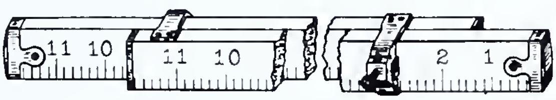


Fig. 108 — *Inside-Diameter Scale*

Inside-Diameter Scale

This tool (Fig. 108) is a combination of two scales which are loosely bound together with metal sliding loops. A thumb screw in each loop provides means to securely lock the two scales at any desired location. When it is necessary to check the inside diameter of a large cylinder, the distance between two plates, or the distance between flanges on the inside of a cylinder or tank, the scales can be passed by each other until the ends contact the surfaces of the work. The thumb screw is then tightened and the measurement is read on the scale. The scale can also be tele-

scoped and a measurement can be taken between two surfaces that cannot be reached with an ordinary scale.

Pinch Bar

This tool (Fig. 109) is used to align holes and to lift the edge of a plate or other similar objects. One end is rounded and tapered like a drift and the opposite end is flattened to a chisel edge. The pinch bar also is used to adjust lifting pads and chains and to tighten heavy cap screws and jack screws.

Fig. 109 — *Pinch Bar*

Lifting Pads

Two types of lifting pads are shown in Fig. 110. The illustration at *A* shows a lifting pad which is used to lift rings or cylinders. Crane chains or hooks are fastened to the loop in the lifting pads and the pad hooks have a tendency to pull in toward the work and so keep them from slipping off.

The illustration at *B* shows a lifting pad which is used to lift plates. The edges of the pads are beveled to permit entrance of the pad between plates that are piled on the floor. Several plates may be lifted at one time. Crane chains, or hooks, are fastened to the loop in the lifting pads and the pad plates have a tendency to pull in toward the work and so keep them from slipping off.

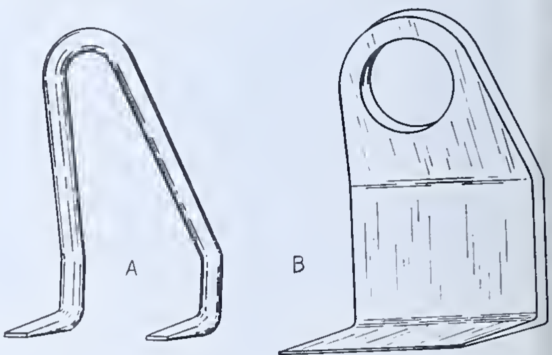


Fig. 110 — *Lifting Pads*

Hand Hammer

The hand hammer shown in Fig. 111 is a utility tool that serves many purposes. It can be used to knock off tack-welded clips, to drive wedges, to adjust plates along the edges with other plates, to drive a calking tool, to drive rivets and pins, and to do many other similar jobs. It is too heavy (approximate weight 2 lbs.) to use, in many cases, as a ball-peen hammer is used. It should not be used on a job where a sledge or a maul is required.

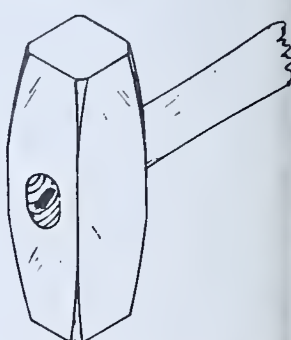


Fig. 111 — *Hand Hammer*

PART III
DESCRIPTION AND USE OF STEEL

INFORMATION SHEET NO. 1
STEEL STOCK

General Information

Steel in some (shape or) form is the principal material used in boilershop practice. Most of the steel used is received in the form of flat plates of various thicknesses. Rolled steel shapes also are used in the construction of many jobs. Flat plates are cut into smaller plates and strips. The smaller plates and strips are passed through bending and forming machines for the purpose of working the metal into cylindrical, angular, and irregular shapes according to the information given on the blueprint.

Characteristics of Steel

There are many grades of steel, just as there are many grades of wood, cloth, paper, etc. Galvanized iron is a grade of steel. Ordinary gas pipe is made from a grade of steel. Razor blades are made from a grade of steel. Files are made from a grade of steel. Armor plating is made from a much better grade of steel than any of the foregoing articles mentioned. The way the steel is made and the nature of the materials of which the steel is composed make the difference in the grade of the finished steel plate or shape.

Analysis of Steel

A loaf of bread is a very common necessity. It is well known that the principal material used in making bread is flour. Other materials used are yeast, sugar, lard, and water. The amounts of the materials used vary greatly. A list of the materials used in making a grade of steel with the amount of each material used is called an analysis of the steel.

The analyses of steels vary considerably. The principal material used in making steel is iron. The principal difference between iron and steel is the amount of carbon. Iron contains a great amount of carbon; steel contains very little carbon. Carbon produces the same effect in steel that starch produces in a shirt collar. A shirt collar without starch is limp and can be folded easily. A starched shirt collar is stiffened, and it will crack if a large amount of starch is used.

Metal Alloys

Certain metals are mixed with the iron when steel is prepared for casting into billets. A billet is a heavy chunk from 12″ to 18″ round or square, and about 30″ long (or longer). The steel mixture is brought to a temperature of about 4000° F. and is then cast into billets. Small amounts of carbon, silicon, vanadium, molybdenum, titanium, manganese, or nickel are mixed in with the iron. These additions distribute themselves throughout the molten metal, and the mixture is then known as an alloy. Any alloy is composed of two or more metals that will mix together.

Tensile Strength

When two men pull on opposite ends of a rope, the rope is under strain lengthwise. The men cannot pull the rope apart lengthwise, because it is too strong. If the same rope is fastened between two powerful locomotives, the strain on it will be greater. If the locomotives are powerful enough, the strain will be great enough to pull the rope apart. This lengthwise strain on material is called a tensile strain. The tensile strength of material is the amount of strain, in pounds, that the material will withstand before it pulls apart.

Different grades of steel have different tensile strengths. The tensile strength depends upon the kinds and amounts of alloys that are used in mixing the steel.

Since the steel plates will be subjected to tensile (stretching) strains as they are being worked to shape in the shop, it is very important that some mark of identification should be put on the plates before they leave the steel mill so that the shop may know that one pile of plate contains high-grade steel while another contains a different grade of steel.

Identification of Steel Stock

When steel stock is ordered from the mill, the order specifies the analysis, the tensile strength, the thickness, the width, and the length of the plate, and the purpose for which it is to be used.

As each lot of plates is rolled, a specimen test bar is made from the same "heat" and tested for strength and quality. When the steel is tested and inspected, the inspector stamps each piece with the manufacturer's name, the locality of the steel mill, (the grade of steel), and the tensile strength. Look for these markings on plates. The marks are stamped on two opposite diagonal corners about 18″ from the edge of the plate.

Rolled steel shapes are marked in a similar manner with the name of the marker and the locality of the mill. The blueprint will specify the grade of steel to be used for the job, the thickness of the plate, and the tensile strength. The stock piles in the yard are so arranged that each pile contains the same grade and thickness of plate. The tensile strength is stamped on the steel: T.S. 55000, T.S. 65000, T.S. 70000, and so on, up to as high as 90000. The figures mean the number of pounds strain per square inch that the particular grade of steel will withstand.

Grades of Steel

The grades of steel usually purchased for boilershop practice are listed below.

Flange steel	T.S. 55000 — 65000 — 70000
Firebox plain	T.S. 55000 — 70000
Firebox silicon kilned	T.S. 55000 — 70000
	T.S. 90000 — special
Marine firebox	T.S. 55000 — 70000

Uses of Steel

No. 1 Firebox steel is used for making boilers, and thick-walled vessels that have to withstand high pressures. Grades of higher tensile strength contain molybdenum, titanium, vanadium, and nickel. Where light weight is desirable, the steels of higher tensile strength are used because the plates can be rolled thinner without sacrificing strength.

Boiler-plate steel is divided into two main classifications: firebox steel and flange steel. Plates that are marked at the mill as "MARINE STEEL" and have the inspector's stamp "U. S." indicate that they have been government-inspected for marine use.

Steel which contains nickel and manganese is used where high temperature or corrosion is encountered. Tanks and structural steel are of about the same grade. Flange steel is used on thinner-walled, low-pressure vessels and parts of boilers where the load is not so great. Sheet steel is a poorer grade of steel. Steel plate 3/16″ thick, or less, is called sheet steel.

Tank and structural steel are used in the construction of stacks, uptakes, breechings, and other steel structures. Tank steel is used in tanks which do not require certified boiler plate.

Certified Steel

All stay-rod steel, stay-bolt steel, stay-rod nuts, braces, brackets, rivets, bolts, pins, tubes, manhole heads, reinforcing plates, nozzles, pads, beams, and sling-stays must be certified stock if used in the construction of boilers or pressure vessels unless otherwise specified on the drawing.

Certificates of the tests of these materials are furnished by the mill after the specimen has been tested.

Normalizing Steel

Steel plates which are 2″ thick, or over, are heated to a high temperature and then rapidly cooled to make the structure of the steel more even. This is called normalizing. Plates which are less than 2″ thick do not require this treatment except in special cases.

After severe bending, forming, or heavy welding, or any combination of these, a moderate heat treatment is necessary, especially if the plates are thick. This is another form of normalizing and is called stress relieving.

Steel becomes brittle at freezing temperatures. This condition does not occur at summer temperatures. Steel should be preheated and kept warm during bending, forming, and setting operations when such operations are performed in cold weather.

Identifying Defective Steel Plates

There may be present in steel plates certain defects that often cause trouble if not detected before the plates are worked. Some of these defects are listed below.

Laminations — Laminations are spots that show on the edge surfaces of the plates and make the edges look like a steel sandwich. They are caused by plate parts that did not knit together well when the plate was rolled.

Blisters — Blisters are bubble-like formations near the surface of the plate. They are caused by imprisoned gases which were present when the plate was rolled. The billet from which the plate was made was not worked enough to force all of the slag out of the steel mass. The gases were trapped near enough to the skin of the plate for the expansion of the gas to raise a blister.

Pockmarks (Mill Marks) — When foreign substances, such as flying slag, cold shot, or balls of scale are caught on the plate as it is going through the rolls, the plate becomes pitted and badly marked. The plate is much weakened where these marks occur.

Under Thickness — Plates are sometimes rolled undersize. There are many reasons for this lack of standard thickness. When the rolls are set for plates of a certain thickness and temperature, an extremely hot plate will become slightly undersize when it cools. Then, too, the operator may make the wrong adjustment on the rolls and produce a thin plate. Sometimes, too, the adjustment can slip and two or three plates may be rolled before the error is discovered.

Undersize plates should be used with caution. It is better to use plates .020″ to .025″ thicker than to use plates that are that much thinner. When heads are being made, the plate should be selected 1/8″ thicker than required so that the amount of stretch on the round corner or knuckle will not cause a spot thinner than specified on the blueprint.

Snakes (or scabs) — A snake (or a scab) shows up as a long, rope-like ridge or a rough, raised irregular area on the plate surface. Passing a plate with such imperfections through the rolls in the shop is likely to cause serious trouble.

Inspect all stock carefully to avoid working a plate or other steel shape that has any of the foregoing defects. Consult the foreman or leader if in doubt.

Code Vessels

The term “code vessel” is applied to any boilershop construction that is made according to standard specifications.

The American Society of Mechanical Engineers and the American Petroleum Institute furnish specifications for thickness and grade of steel plate that must be used in

various types of jobs. All finished work is tested and inspected, and if it is found that the steel plate used is not up to specifications, the inspector rejects the entire job.

It should be quite clear from the foregoing that great care must be exercised in selecting steel stock for any job. Measure the thickness of the plate carefully, and check the mill mark to make certain that it is the correct grade and tensile strength for the job. Steel stock that shows defects listed under "Identifying Defective Steel Plates" should be rejected unless the defects can be cut out and the stock used for a smaller-sized job.

Hot-Rolled Shapes

Hot-rolled shapes are listed below. They are called hot-rolled shapes because the steel billets are brought to a white-hot temperature at the steel mill and then passed between rolls and squeezed into the desired shapes.

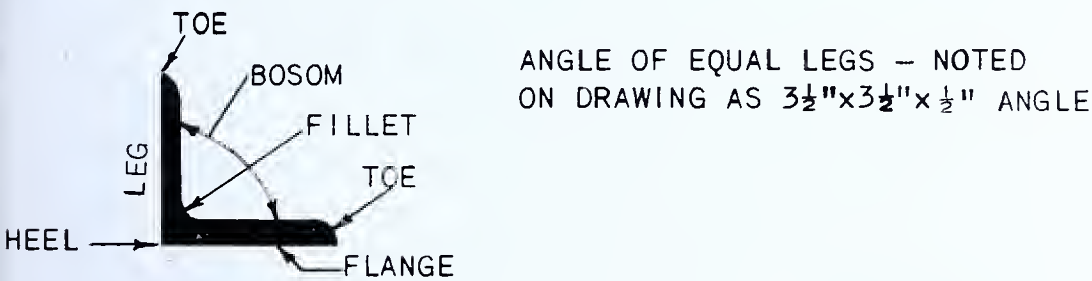


Fig. 112 — *End View of a Length of Angle*

Angle Iron — Steel angle is usually called "angle iron" in the shop. The end view in Fig. 112 indicates the correct names of the surfaces and corners. When making a requisition for a length of angle, write it as follows:

1-pc. — ½″ x 3½″ x 126″ angle.

The ½″ dimension is the thickness of the legs.
The 3½″ dimension is the width of the flange surface, or length of the legs.
The 126″ dimension is the length of the piece of angle.

When the legs of the angle are not equal the size is given as follows:

1-pc. — ½″ x 2½″ x 3½″ x 126″ angle. The smaller dimensions are given first.

When the legs of the angle are not equal and the thickness of one leg is greater than the other, the size is given as follows:

1-pc. — ⅜″ x 2½″ x ½″ x 3½″ x 126″ angle. The thickness and length of the short leg and the thickness and length of the long leg are given as indicated. The length comes last. Angles usually are rolled in 20-foot lengths at the mill. They have to be cut to length on the job. Lengths may be welded to form longer lengths if required.

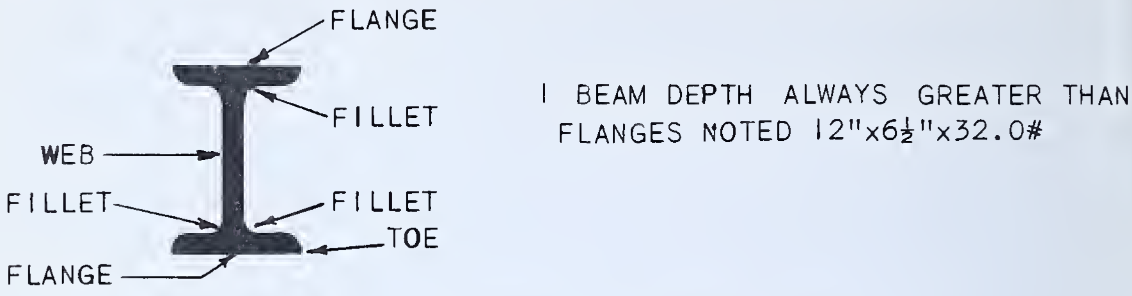


Fig. 113 — *End View of a Length of I Beam*

I Beam — The thickness of the web shown in the end view of the I beam, Fig. 113, is standard for the depth of the section. When measuring an I beam or when stating the size on a requisition, the depth is considered first. The size is written as follows.

1-pc. — 12″ x 6½″ x 32.0# x 128″ I beam.

The 12″ dimension is the depth from flange to flange.

The 6½″ dimension is the width at right angles to the depth.

The 32.0# means that the I beam weighs 32 lbs. for each foot of length.

The 128″ dimension is the length of the I beam.

A lighter I beam has the same depth and width, but the stock is thinner. The weight for each foot of length might be 25 lbs.

I beams usually are rolled in 20-foot lengths at the mill. They have to be cut to length on the job. Lengths may be welded to form longer lengths if required.

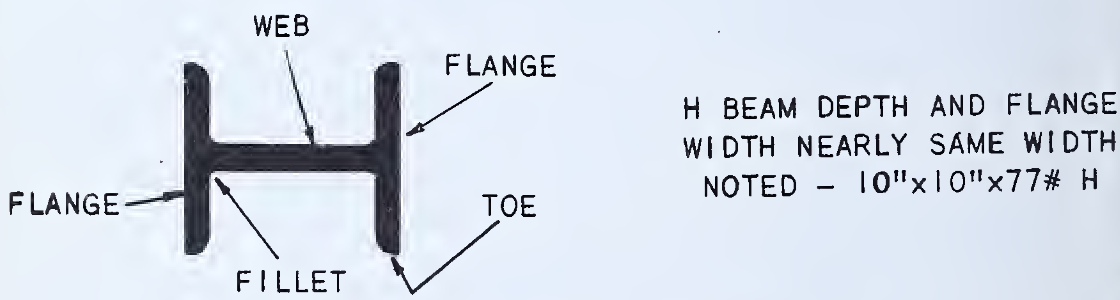


Fig. 114 — *End View of an H Beam*

H Beam — The H beam shown in Fig. 114 is another form of rolled steel. Do not confuse an H beam with an I beam. The H beam is about the same depth as the width of the flange. When a requisition for an H beam is written, the sizes are given as follows:

1-pc. — 10″ x 10″ x 77# x 140″ H beam.

The first 10″ dimensions is the depth.

The second 10″ dimension is the width of flange.

The 77# means that the H beam weighs 77 lbs. for each foot of length.

The 140″ dimension is the length to which the H beam is to be cut.

FIG. 115 — *End View of a Channel*

CHANNEL — The channel shown in Fig. 115 is a commonly used rolled steel shape. It is much like a double angle, and the thickness of the channel legs and the channel web is approximately the same. The legs are usually the same length. When a requisition for a channel is written, the sizes are given as follows:

1-pc. — 10″ x 3½″ x 23.6# x 97″ channel.

The 10″ dimension is the width from flange to flange.

The 3½″ dimension is the length of the legs.

The 23.6# means that the channel weighs 23.6 lbs. for each foot of length.

The 97″ dimension is the length to which the channel has to be cut.

FLAT BAR — Flat bar is one of the most commonly used rolled shapes. The end view in Fig. 116 shows the proportions of flat bar. The width is usually much greater than the thickness. When a requisition for flat bar is written, the sizes are given as follows:

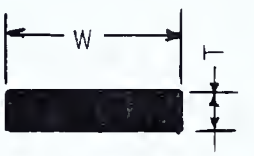


FIG. 116—*End View of a Flat Bar*

1-pc. — ½″ x 1½″ x 86″ flat bar.

The ½″ dimension is the thickness.

The 1½″ dimension is the width.

The 86″ dimension is the length to which the flat bar has to be cut. Flat bar is cut into 20-foot lengths at the mill; it can be welded in the shop to make longer lengths if necessary.

SQUARE BAR — Square-bar stock (Fig. 117) measures the same on all sides. There are many sizes of square-bar stock used in the boiler shop. It is cut into various lengths and welded, bolted, or riveted to other members of some fabricated structure.

When a requisition for square stock is written, the sizes are given as follows:

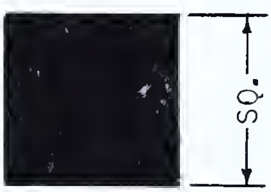


FIG. 117—*End View of Square Bar*

1-pc. — ⅞″ square x 72″, or, 1-pc — ⅞″ x ⅞″ x 72″ square bar.

The size of the square is given first, the length next, and the name of the bar last. Square bar is cut into 20-foot lengths at the mill.

ROUND BAR — There are many sizes of round-bar stock (Fig. 118) used in the boiler shop. It is cut into various lengths and welded to other members of some fabricated structure. Bolts, studs, tie rods, pins, twist drills, reamers, and many other such articles are made from round-bar stock. When a requisition for round-bar stock is written, the sizes are given as follows:

1-pc. — ¾″ diameter x 60″ round bar.

The diameter size is given first, the length next, and the name of the bar last. Round bar is cut into 20-foot lengths at the mill.

FIG. 118—*End View of Round Bar*

SPECIFIC GRADES OF STRUCTURAL STEEL

Structural steel shapes are made in many grades. The analysis of the stock required is specified when the order is sent into the mill. The A.S.M.E. (American Society of Mechanical Engineers) and the A.P.I. (American Petroleum Institute) have established standard specifications for all grades of steel. Since all grades of steel look much alike, it is necessary to look for the mill mark on each piece to be sure the right grade is received. This is primarily the duty of the stock clerk, but everyone concerned should do his part to make sure that the right grade and the right size of steel stock is being used on the job for which it is intended.

FIG. 119 — *End Views of Boiler-Tube Stock*

BOILER TUBING — Boiler tubing (Fig. 119) is made from specially drawn steel stock. Generally there are three weights (wall thickness) of boiler-tube stock used. Specifications and weight of tubes are given when this stock is ordered from the mill. The stock is inspected and marked in the same manner as other steel stock. Look for the mill mark and the size before cutting this material for the job.

The term X-heavy is read "extra heavy"; XX-heavy is read "double extra heavy."

QUESTIONS

1. What mill markings are usually found on a piece of marine boiler plate?
2. Where are the mill markings located on the boiler plate?
3. Why is it essential that the mill markings be placed in such a position when the plate is being worked that they can be seen plainly after the job is completed?
4. How many grades of steel plate are used in the construction of fire tube boilers?
5. Specify the materials which must be certified before they may be used in boiler construction.
6. The bill of material specifies one piece of angle ½″ x 3½″ x 3½″ x 126″ long. Describe the particular angle to which each of these dimensions refer.
7. State the usual mill lengths of angle stock.
8. Describe the significance of I beam dimensions.
9. State the three dimensions used to specify the size of flat bar stock.
10. What is meant by these stock shapes; angle, flat, round, square?
11. How many dimensions are usually given for a piece of round steel bar?
12. What is the difference between seamless pipe and butt-welded pipe?
13. Is it essential that boiler tubes be certified before being installed?
14. Where are the markings found on boiler tubes?
15. Describe the boiler-tube markings.

INFORMATION SHEET NO. 2
BOLTS AND RIVETS

Bolt Sizes for Boilermakers

Bolt sizes in most industrial plants are given as:

1. 4 — 1¾ x ⅝ machine bolts.
2. 5 — 2 x ¾ carriage bolts.

Explanation of Bolt Sizes

Item "1" means that there are required four bolts 1¾″ long and ⅝″ in diameter.

Item "2" means that there are required five bolts two inches long and ¾″ in diameter.

"Machine bolt" refers to the type of bolthead. The types of boltheads generally used are shown in Figs. 120, 121, and 123.

The diameter of the bolt is often given first as:

⅝ x 1¾ and ¾ x 2. The letter x means "by" when used in this connection. The sizes are always understood to be given in inches unless otherwise specified.

Boilermaker Bolts

A simple system is used for identifying the size of bolts used in boilermaking. See the table given below. It is a partial list of bolts commonly used.

Table No. 1

		No. Required
5 — B — 8	= ⅝ x 1″	12
5 — B — 9	= ⅝ x 1⅛″	24
5 — B — 10	= ⅝ x 1¼″	6
5 — B — 11	= ⅝ x 1⅜″	18
5 — B — 12	= ⅝ x 1½″	22
5 — B — 13	= ⅝ x 1⅝″	16
5 — B — 14	= ⅝ x 1¾″	20

The column on the left of the equality signs gives the bolt sizes as they are found on a blueprint in the boiler shop. The column on the right of the equality sign gives the bolt sizes as they are found in most industrial plants.

Explanation of Table of Bolt Sizes

1. The first figure means the size of the bolt in eighths of an inch.
2. The *B* means bolt.
3. The last figure means the length of the bolt in eighths of an inch.

   For example: 5 — B — 9 refers to a bolt which is ⅝ of an inch in diameter and 9/8″, or 1⅛″, long. 5 — B — 29 refers to a bolt which is ⅝ of an inch in diameter and 29/8″, or 3⅝″, long.

Bolt and Nut Steel

Ordinary stock bolts are made from a tough grade of steel of about the same tensile strength (55000) as flange steel. The bolts are not polished or machined in any way except for being threaded. They are often referred to as black iron bolts. The nuts also are rough-finished. See Fig. 120.

Medium-finished bolts are made from about the same grade of steel as ordinary bolts. They are machine-finished under the heads so that they will seat tightly on the job. See Fig. 121.

Bolts and nuts made of high-test alloy are usually stamped to indicate specific uses. They are finished all over (F. A. O.) and afterwards polished. These bolts and nuts are used where great holding power is necessary and also in places where the appearance of the finished job must be considered.

Bolts used in boilermaking practice range from 3/8″ diameter and 1″ long to 1 5/8″ diameter and 16″ long. Special sizes are made as required to suit any job where bolts are used.

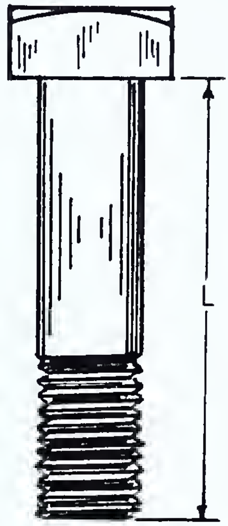


Fig. 120 — *Rough Bolt*

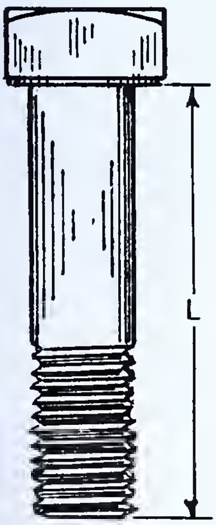


Fig. 121 — *Medium Finished Bolt*

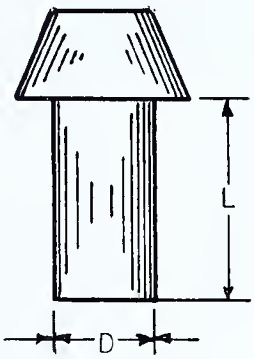


Fig. 122 — *Boiler Rivet*

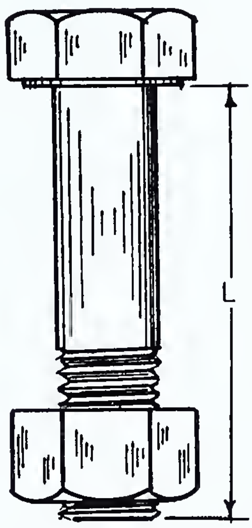


Fig. 123 — *High Test Alloy Bolts F.A.O.*

Boiler Rivet

Boiler rivets are measured for length under the head as shown in Fig. 122. The diameters of boiler rivets run from 3/8″ up to 1 3/4″. The lengths vary according to the diameters of the rivets. A rivet 3/8″ D and 1″ L is about the smallest rivet used in the boiler shop. Boiler rivets are made from certified stock. The rivet shown in the illustration is a cone-head rivet. A pan head is not quite so high as a cone head.

QUESTIONS

1. Describe a 1¾″ x ⅝″ machine bolt.
2. Between what two points is the length of a machine bolt measured?
3. How are square-head bolts and nuts classified in reference to finish?
4. What is the difference between an ordinary bolt or nut and a medium finished bolt or nut?
5. How is the difference determined between an ordinary bolt and nut and an alloy-steel bolt and nut?
6. What dimensions are used when rivets are ordered?
7. What is the difference between a pan-head and a cone-head rivet?
8. Are boiler rivets made from certified bar stock?
9. What is understood by "standard threads" on bolts and nuts?
10. Do all the bolts and nuts used in boiler erection or repair work have standard threads?

INFORMATION SHEET NO. 3
WORKING FROM A BILL OF MATERIAL

General Information

The blueprints which are received in the shop show line drawings of the parts to be fabricated. (Fabricating means cutting out and putting together.) There may be as few as five pieces required to fabricate a job, or there may be as many as fifty. Some of these pieces are made up in one of the shops and delivered to the storeroom for future use. Other pieces are purchased from outside manufacturers and when received they are sent to the storeroom to be put away for future use. Because there are so many different pieces and so many different jobs, it is necessary to number both the pieces and the jobs so that they may be identified at the time they are being made in the shop, received from the manufacturer, or requisitioned from the storeroom.

The Blueprint Number

All blueprints are numbered in code. For example, let us suppose a drawing, No. F.1131-202-856-1, is received in the shop. There are many such drawings received at one time, and each one may be a detail taken from an assembly drawing which carries the same code numbers F-1131-202-901-4. It will be seen that the first letter and the first two numbers are the same on the assembly drawing and on the detail drawing (F-1131-202). The F-1131 is the code number. The 202 is the boat, or contract, number. The 901-4 refers to the assembly drawing. The 856-1 refers to the detail drawing. The figure 856 is the piece number and the "1" is the piece mark (pc. mk.). There is a piece mark for each individual piece that goes into the making up of the finished job as far as this particular blueprint is concerned. See Fig. 124.

Most blueprints have numbers placed in circles all around the views of the line drawing. See Fig. 125. Lines lead from the outside of these circles to some point indicated by an arrowhead in one of the views. The meanings of these numbers will be explained in the next paragraph.

Typical Bill of Material

A bill of material is sent into the shop with every blueprint. In that there are hundreds of these bills of material, they are kept in a large file which opens like a book. An example of a bill of material is shown in Fig. 124. The numbers given in the column headed "Pc. No." correspond to the numbers in the circles around the views of the line drawing on the blueprint. As an example of identifying piece mark (pc. mk.) Fig. 124 shows two pieces marked -2. Referring to the bill of material we find in the second item from the top piece that there are to be four side plates made from tank steel. The sizes of the plates are 26″ x 74″ x 1/4″ thick. The bill of material also gives other information which will be explained later.

SUN SHIPBUILDING & DRY DOCK CO.

180 (5) BILL OF MATERIAL

Charge To No. F-1123-204 Name 250 GAL. CENTRIFUGED L.O. TANK 250 GAL. L.O. STORAGE TANK Assembly Draw No. F-1131-202-901-4 Date March 17, 1942 B/M No. 180

No. Pcs.	Description	Material	Pattern No.	Remarks	Drawing No.	Pc. No.	P.O.No. or Stock	Routing	Mater'l Rec'd	Work Finished
2	250 GAL. TANKS		COMPLETE	CENTRIFUGED L.O.TANK (1) L.O. STORAGE TANK (1)		861		30-36		
4	BOTTOM & TOP PLATES	TANK ST.		26" X 36" X 1/4" THK.		-1		75-30-36		
4	SIDE PLATES	"		26" X 74" X 1/4" THK.		-2	S	"		
4	FRONT & BACK PLATES	"		36" X 74" X 1/4" THK.		-3	S	"		
2	SWASH PLATE	"		24" X 34" X 1/4" THK.		-4	S	"		
2	MANHOLE COVER PLT.	"		15" X 19" X 1/2" THK.	F-1131-202-856-1	-5	S	"		
2	MANHOLE COVER RING	"		15" X 19" X 3/4" THK.		-6	S	"		
2	GASKET	OILENE		15" X 19" X 1/8" THK.		-7	S	80-30-36		
4	HANDLES	STL.		1/2" DIA. ROD 12" LG.		-8	S	80-42-30-36		
24	STUD & NUT	"		3/4" DIA. X 2-1/4" LG.		-9	S	80-36M-30-36		
10	3/4"-90° ELBOW-SCR.	M.I.		GAUGE CONNECTIONS		-10	S	80-34-30-36		
10 FT.	3/4" PIPE STD. WT.	SEAMLESS STL.		GAUGE CONNECTIONS		-11	S	"		
12 FT.	1-1/4" PIPE STD. WT.	"		SUPPLY CONN. FROM PUMP		-12	S	"		

FIG. 124—*Typical Bill of Material*

Shop Routine

The blueprints come to the boilershop foreman directly from the engineering department. The foreman examines the blueprints carefully. He begins with the assembly

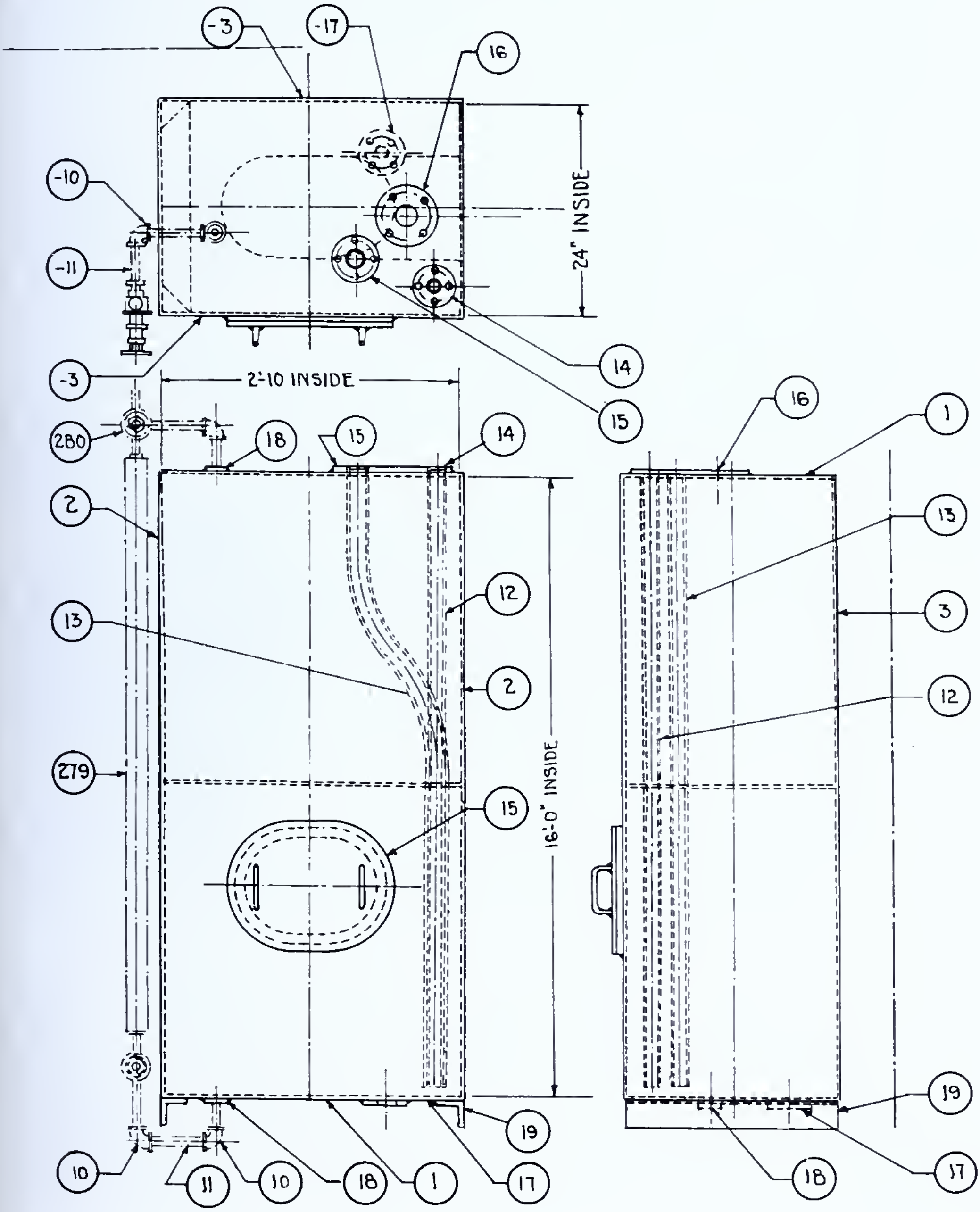


Fig. 125 — *Blueprint Showing Piece Marks*

and goes through all the details. He selects the particular job which, in his estimation, should come first and hands the blueprints thus selected to the boss layer out. He also hands the boss layer out a complete bill of material which came with the

blueprint and on which all the piece marks are listed as explained above. The boss layer out places these bills of material in his bill of material file. He assigns the blueprints to his crew of layout men and charges them with the responsibility of obtaining the necessary materials. Each layout man has access to the bill of material file and from this file he checks with the blueprint and finds the size, kind, and source of material required. The source of the material is plainly shown on the blueprint under the heading marked "Routing".

Routing of Material

Refer to Fig. 124 bill of material. Opposite the first piece mark in the column headed "Pc. No." is -1. In the column headed "Description" is found "Bottom and Top Plates". In the column headed "Routing" is found "75-30-36". These figures mean that the plates are routed through the departments whose numbers appear in this column. In this case, the bottom and top plates of tank steel are found in Department 75, which is steel stores or plate yard. The layout man fills out a requisition for the steel stock required and hands the requisition to the expediter. The expediter is the man who chases stock and parts. He checks with the proper authorities to find out if the stock is in the yard; then he locates the material. If the stock is available, it is delivered to the next department indicated by the figures in the column headed "Routing". In this case, Department No. 30 is the boilershop.

The plates are laid out, the piece mark is put on with white paint (for example, pc. mk. 240-1), and the plates are laid to one side until required. Farther down in the column headed "Description" there is an item stud and nut, steel, $\frac{3}{4}''$ diameter x $2\frac{1}{4}''$ long, piece mark -9, routed 80-36M-30-36. The 80-36M-30-36 means that the material is found in Department No. 80, is taken to Department No. 36M for machining, and is then brought into Department No. 30, the boilershop, to be assembled with other parts.

It will be seen that the last department number under "Routing" on this Bill of Material is 36. This 36 means that when the entire job has been completed, inspected, and approved, it is delivered to Department No. 36, Installation.

Purchased Material

Some of the parts for a particular job may be purchased from a manufacturer. The piece number given on the blueprint may be -23. The bill of material will identify this piece as, "1 required, $\frac{3}{8}''$ x 3′ flanged and dished head." The piece number and circle on the line drawing are marked in red. Material code number is placed on the bill of material in column headed "P. O. No. or Stock" (Purchase Order Number). The letter "S" in this column indicates that the material is in stock. The word "buy" in this column indicates that piece is purchased.

Closing Out the Routing Schedule

When the bill of material is received (see Fig. 124) it carries a number to which all the work is to be charged and so recorded on the time ticket. The name of the job or jobs to be fabricated are given, the date on which the bill of material was issued is written in, and the bill of material number is given at both sides at the top.

The two columns at the right are filled in by the shop as indicated. The two columns after routing show the date the material was received and the date when the work was finished and delivered to the next department. A comparison of the bill of material with the blueprint at the final checking will indicate whether or not the job is complete and ready to be inspected.

QUESTIONS

1. **What is understood by the term "bill of material"?**
2. **Explain the purpose of a bill of material.**
3. **What purpose does the blueprint code number serve?**
4. **How many bills of material are there for each job number?**
5. **How is the piece shown on the blueprint identified on the bill of material?**
6. **What materials are used on the job that are not shown on the bill of material?**
7. **What is understood by the term expediter?**
8. **Explain the duties of an expediter.**
9. **How can the expediter determine from the bill of material where the stock is to be found?**
10. **In what may does the expediter assist the mechanic in procuring materials needed for the job?**

INFORMATION SHEET NO. 4
HANDLING MATERIALS

General Information

Materials must be transferred from one part of the boilershop to another; from piles on the floor to machines; from the machines to other machines; and from the floor to railroad cars. Traveling girder cranes (Fig. 126) are located on special tracks. The tracks are suspended from heavy brackets which are bolted to the side walls of the shop near the roof. There are several cranes running on the same track. The cranes may be used singly or in pairs. For ordinary work only one crane is

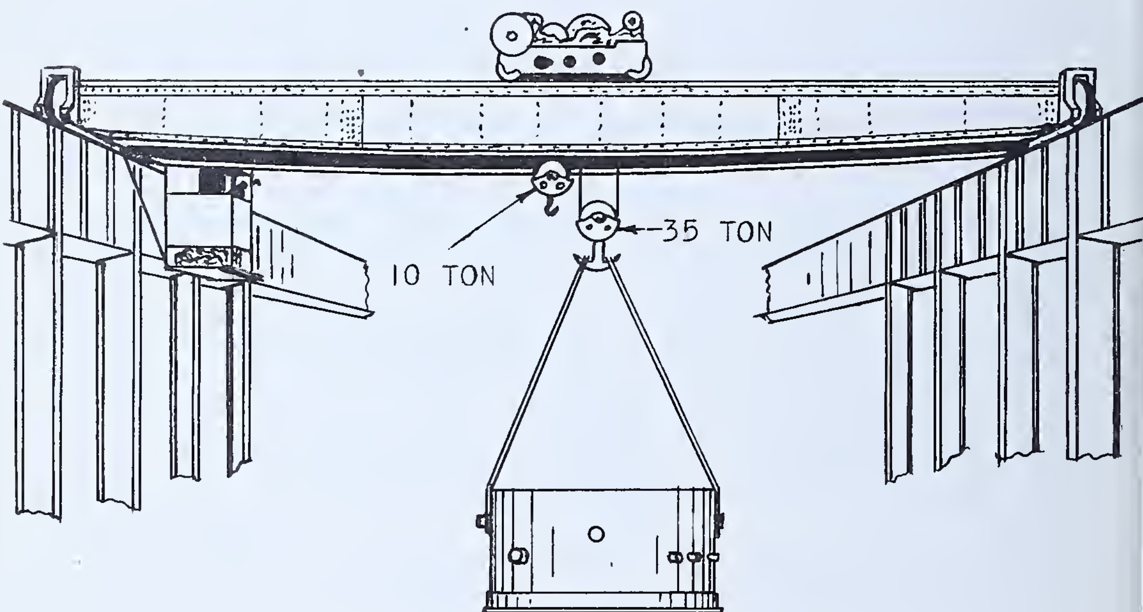


Fig. 126 — *Traveling Girder Crane*

needed. Each crane is equipped with a traveling truck or "dolly". Each dolly i equipped with two electric hoisting motors which operate drums that carry heav wire hoisting cable. Usually one electric hoist has a capacity of 35 tons and the othe electric hoist has a capacity of 10 tons. These capacities may vary considerably bu one hoist is always of greater capacity than the other.

Control

The movements of the crane up and down the shop and the movements of th dolly back and forth on the transverse girder of the crane are controlled from a ca which is suspended from one end of the crane frame. The operator responds to th signals given to him by the crane hook-on man from the floor. The crane hook-o man is the only person authorized to give signals to the crane operator. The cran operator is instructed to ignore any signals given by unauthorized persons. This rul

is established so that accidents can be prevented and responsibility fixed for the movement of materials. The hook-on man has a helper whose duty it is to assist with the securing of the hoisting slings and dogs to the material which is to be moved. The helper never gives signals to the crane operator.

Crane Signals

The crane signals for floor work are shown in Fig. 127.

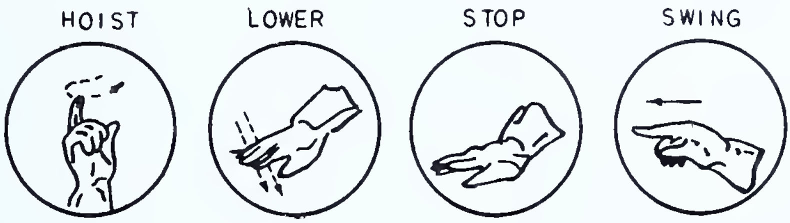


Fig. 127 — *For Floor Work*

The crane signals for machine work are shown in Fig. 128.

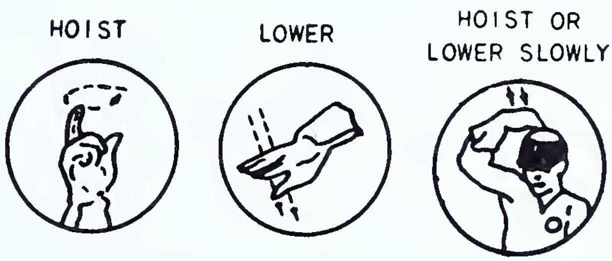


Fig. 128 — *For Machine Work*

The signal for an emergency stop is made by holding the hands palms downward and horizontal with the floor. With the hands held in this position make a circular motion in and out by moving the hands at the wrist. The crane operator will immediately *stop* any crane motion and await further signals.

Lifting Steel Plates

Steel plates are lifted by means of a spreader and lifting pads as shown in Fig. 129. The spreader allows even distribution of the load and also it acts as a stiffener to keep the plates from sagging. The chain slings transmit a vertical lift to the lifting pads which eliminates slippage.

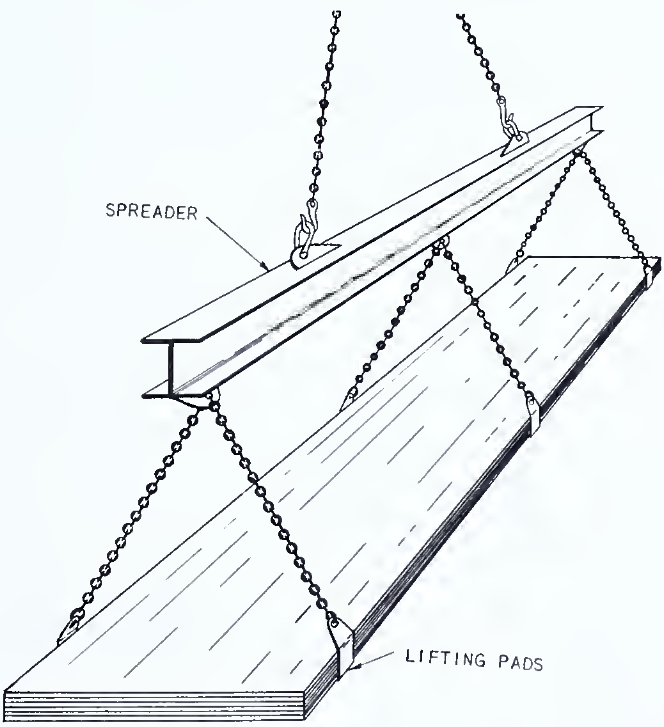


Fig. 129 — *Lifting Steel Plates*

Lifting Circular Plates

Single plates (Fig. 130) are lifted by using a cable sling and lifting pads. Care must be taken to place the lifting pads in the center of the plate.

Circular plates are lifted by means of a three-part sling

(Fig. 131) and lifting pads. The lifting pads are adjusted at equal intervals around the circumference of the plate. Be sure the lifting pads are under the edge of the plate before the signal is given to lift. The weight of the load will keep the lifting pads in position.

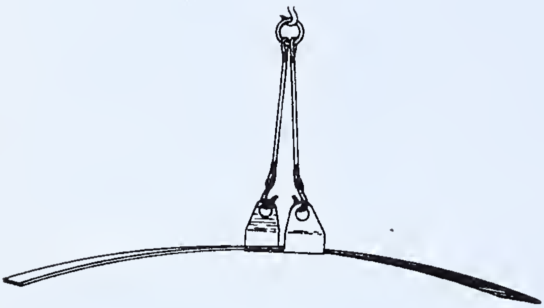


Fig. 130 — *Lifting Single Plates*

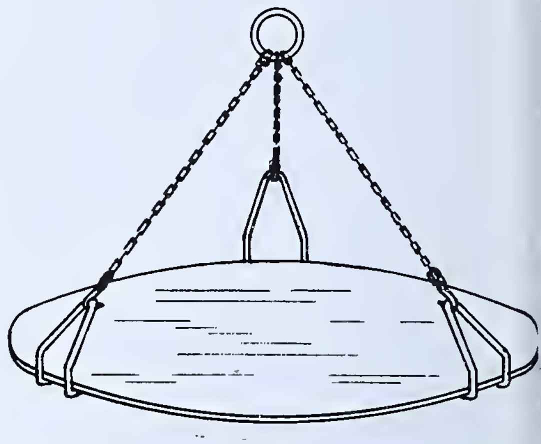


Fig. 131 — *Lifting Circular Plates*

Turning Work Over

By using both crane-hooks work can be turned over. The dished head shown in Fig. 132 weighs about seven tons. One crane-hook is secured with a sling to the spigot flange on the head. The other crane-hook is fastened to a chain sling which is hooked into suitable clips that are bolted to the dished-head flange. The smaller crane-hook usually does the turning. When the slings have been made secure the large hook is raised and the small hook is tightened until the dished head is lifted into the position shown in Fig. 133.

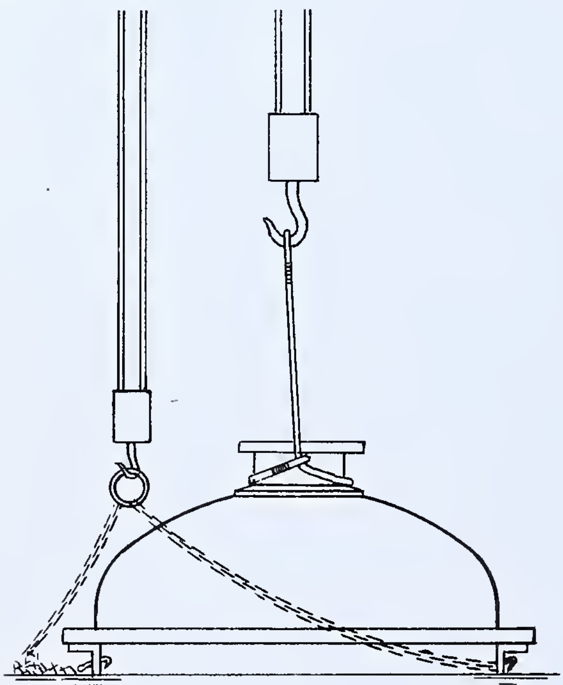


Fig. 132 — *Preparing to Turn a Dished Head*

The small hook is raised more and more until the dished head is balanced between the two hooks. By manipulation of the crane-hooks the operator gets the head flange up and the nozzle flange down and then lowers the job to the floor as shown in Fig. 134.

The crane-hooks are then slacked off, the slings are removed, and the dished head after it has been laid out can be picked up and placed on the boring-mill table.

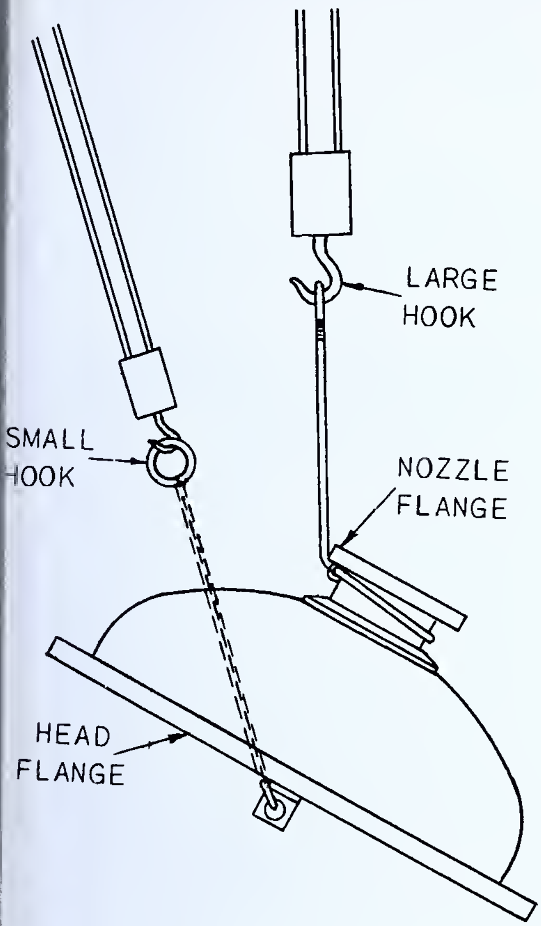


FIG. 133 — *Dished Head Raised from Floor*

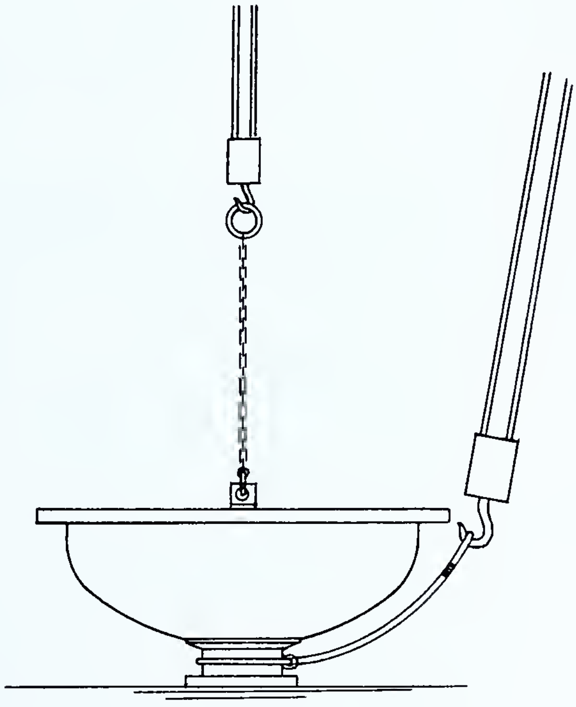


FIG. 134 — *Dished Head Turned Over*

LIFTING TANKS

Heavy and light cylindrical tanks are lifted in a double sling as shown in Fig. 135. The double crane-hook is generally used for this sort of lift. Make sure the cable slings are of the same length. There is some danger of slippage if one cable sling is much longer than the other. Adjust the cable slings near to the ends of the cylinder as shown.

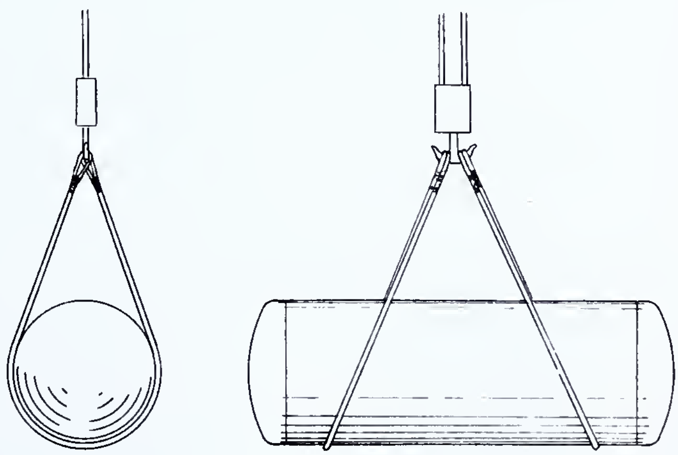


FIG. 135 — *Lifting a Cylindrical Tank in a Sling*

Table No. 2

SAFE LOAD IN POUNDS FOR CHAIN, WIRE ROPE, AND MANILA ROPE SLINGS

DIA.	CHAIN P.D.SPEC. 1591				WIRE ROPE P.D.SPEC. 3105				MANILA ROPE P.D.SPEC. 3106			
	USED STRAIGHT	USED AT 60° ANGLE	USED AT 45° ANGLE	USED AT 30° ANGLE	USED STRAIGHT	USED AT 60° ANGLE	USED AT 45° ANGLE	USED AT 30° ANGLE	USED STRAIGHT	USED AT 60° ANGLE	USED AT 45° ANGLE	USED AT 30° ANGLE
$\frac{3}{8}$	1800	1550	1250	900	2050	1750	1450	1000	200	170	140	100
$\frac{1}{2}$	3000	2600	2100	1500	3700	3200	2600	1850	340	290	240	170
$\frac{5}{8}$	4600	4000	3250	2300	5600	4850	3950	2800	560	480	400	280
$\frac{3}{4}$	6750	5850	4800	3400	8050	7000	5700	4000	690	600	490	350
$\frac{7}{8}$	9350	8100	6600	4670	10800	9350	7650	5400	980	850	690	490
1	12400	10700	8750	6200	14000	12100	9900	7000	1150	1000	810	580
$1\frac{1}{8}$	15600	13500	11000	7800	17600	15200	12400	8800	1550	1350	1100	780
$1\frac{1}{4}$	19200	16600	13600	9600	22000	19000	15500	11000	1750	1500	1250	880
$1\frac{3}{8}$	23000	19900	16300	11500	27200	23600	19200	13600	2240	1950	1600	1100
$1\frac{1}{2}$	27200	23600	19200	13600	32000	27700	22600	16000	2450	2100	1750	1200
$1\frac{3}{4}$	35000	30300	24700	17500	43200	37400	30500	21600	3550	3100	2500	1800
2	44400	38500	31400	22200	52000	45000	36800	26000	4200	3650	2950	2100
$2\frac{1}{2}$	69600	60300	49200	34800	85600	75100	60500	42800	6100	5300	4300	3050
3									8550	7400	6050	4300

THE SAFE LOADS SPECIFIED IN THE TABLE ARE FOR EACH SINGLE CHAIN, WIRE OR MANILA ROPE WHEN USED DOUBLE, OR IN ANY OTHER MULTIPLE, THE LOAD MAY BE INCREASED PROPORTIONATELY. IF, FOR EXAMPLE, THE SLING HAS THREE LEGS, THE LOAD MAY BE THREE TIMES THE LOAD SPECIFIED ABOVE. STUB HOOKS TO BE USED FOR LIFTING APPARATUS, WHICH IS PROVIDED WITH HOLES FOR THAT PURPOSE.

APPROXIMATE WEIGHT OF ONE SQUARE FOOT OF BOILER PLATE

THICKNESS IN INCHES	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
WEIGHT IN POUNDS	$2\frac{1}{2}$	5	$7\frac{1}{2}$	10	$12\frac{1}{2}$	15	$17\frac{1}{2}$	20	25	30	35	40	45	50
THICKNESS IN INCHES	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
WEIGHT IN POUNDS	55	60	65	70	75	80	90	100	110	120	140	160	180	200

APPROXIMATE WEIGHT OF ONE FOOT OF ROUND AND SQUARE STEEL BAR

SIZE IN INCHES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ROUND (IN POUNDS)	$2\frac{3}{4}$	11	24	43	67	96	130	170	220	265	325	385	455	525
SQUARE (IN POUNDS)	$3\frac{1}{2}$	14	31	55	85	123	167	220	275	340	410	490	575	670
SIZE IN INCHES	15	16	17	18	19	20	21	22	23	24	25	26	27	28
ROUND (IN POUNDS)	600	685	720	865	965	1070	1180	1290	1410	1540	1670	1820	1940	2080
SQUARE (IN POUNDS)	765	870	980	1100	1230	1360	1500	1645	1800	1960	2125	2300	2470	2660

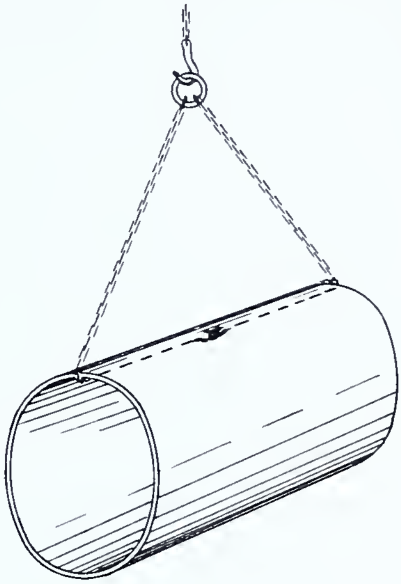


Fig. 136 — *Lifting an Open-end Cylindrical Shell*

Lifting Shells

Cylindrical shells are lifted by means of a long double-hook chain which is passed through the shell and hooked together inside. (Fig. 136) The slack portion of the chain is hooked over the crane-hook. Be sure the chain is placed over the crane-hook so the load will ride level.

QUESTIONS

1. **Good housekeeping and safety go hand in hand. How can the person responsible for handling materials promote good housekeeping?**
2. **How is the crane operator instructed regarding the movements of the block and trolley?**
3. **Is a crane operator qualified to use his judgment as to the safety of the hook-up, the set-up of the rigging, or the condition of the equipment used to handle any material?**
4. **How often should chains, pads, dogs, and shackles be annealed?**
5. **Which is the stronger, a straight lift 1″ chain, or 1″ wire rope?**
6. **How much will 2 square ft. of 1″ boiler plate weigh?**
7. **Explain the correct method for moving a long plate.**
8. **When using pads that are bolted to material, or jobs to be lifted, how much of the bolt end should project through the nut to give it its full strength?**
9. **Can the person responsible for handling material help to keep the shop shipshape? How?**
10. **Material that is delivered to your department by transit should be unloaded as soon as possible. Why?**

PART IV
SHOP FABRICATING MACHINES

MACHINE OPERATION NO. 1
HORIZONTAL BENDING ROLLS

General Information

Many cylindrical shapes to be used later as a main part of some particular boiler job are made up in the boiler shop. These cylindrical shapes are used as storage tanks, pressure tanks, or processing tanks. A cylinder made of ½″ boiler plate is shown in Fig. 137. After the plate has been rolled, it is welded along the seam shown in Fig. 138. Plates up to 2¼″ thick are rolled in this manner. The machine through which the boiler plate is passed is called a horizontal bending roll. The capacity (which means the width of the plate that may be passed through the machine) of machines may vary from 3′ to 18′.

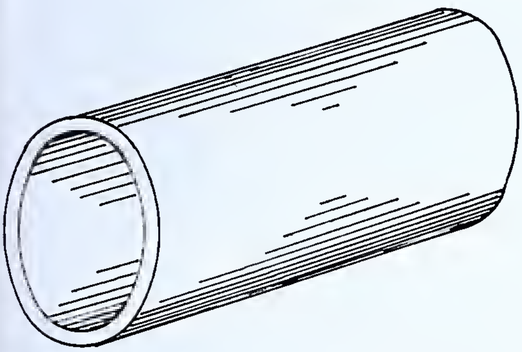


Fig. 137 — *Finished Cylinder*

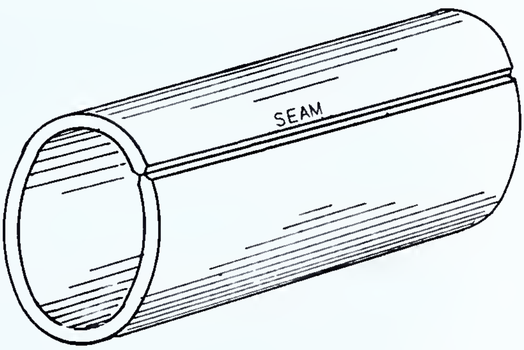


Fig. 138 — *Rolled Cylinder Ready for Welding*

Bending rolls of 6′ capacity are shown in Fig. 139. A bending roll of 12′ capacity is shown in Fig. 140. These bending rolls are operated through a reduction gear by powerful electric motors. The motion of the rolls is controlled by means of a clutch lever shown at *a* in Fig. 139. The electric power is controlled by means of a rheostat shown at *b* in Fig. 139. All bending rolls are controlled in substantially the same manner, although the controlling mechanism may vary in some respects.

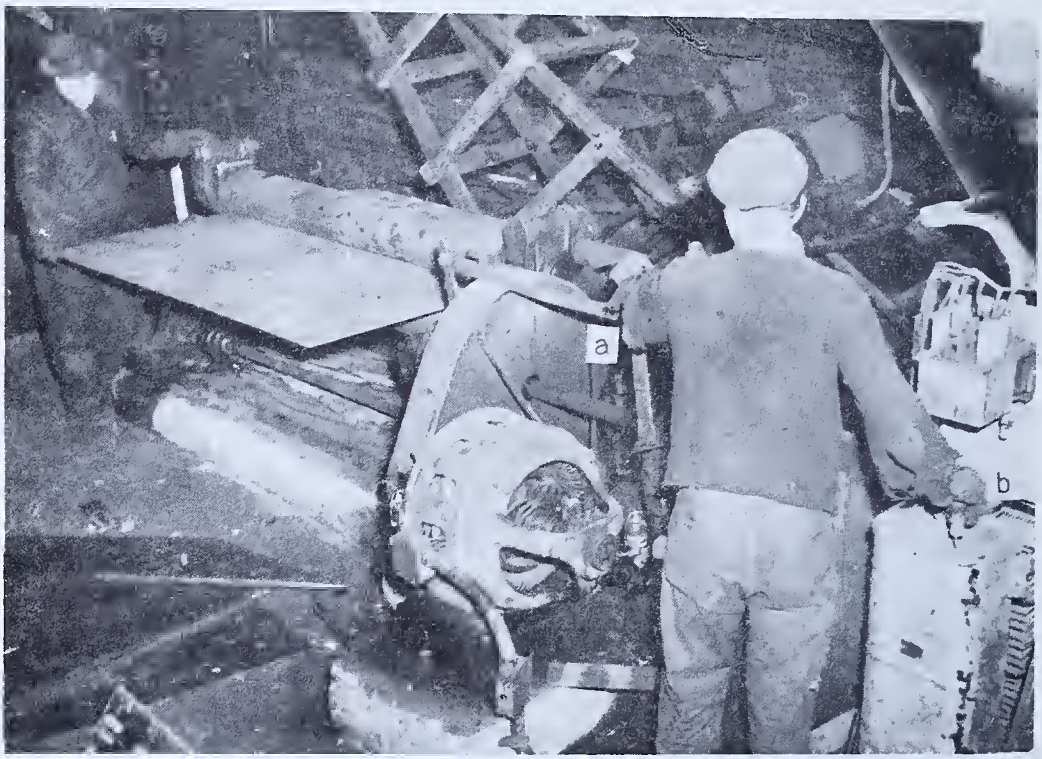


FIG. 139 — *Horizontal Bending Roll — Capacity, 6′ Long*

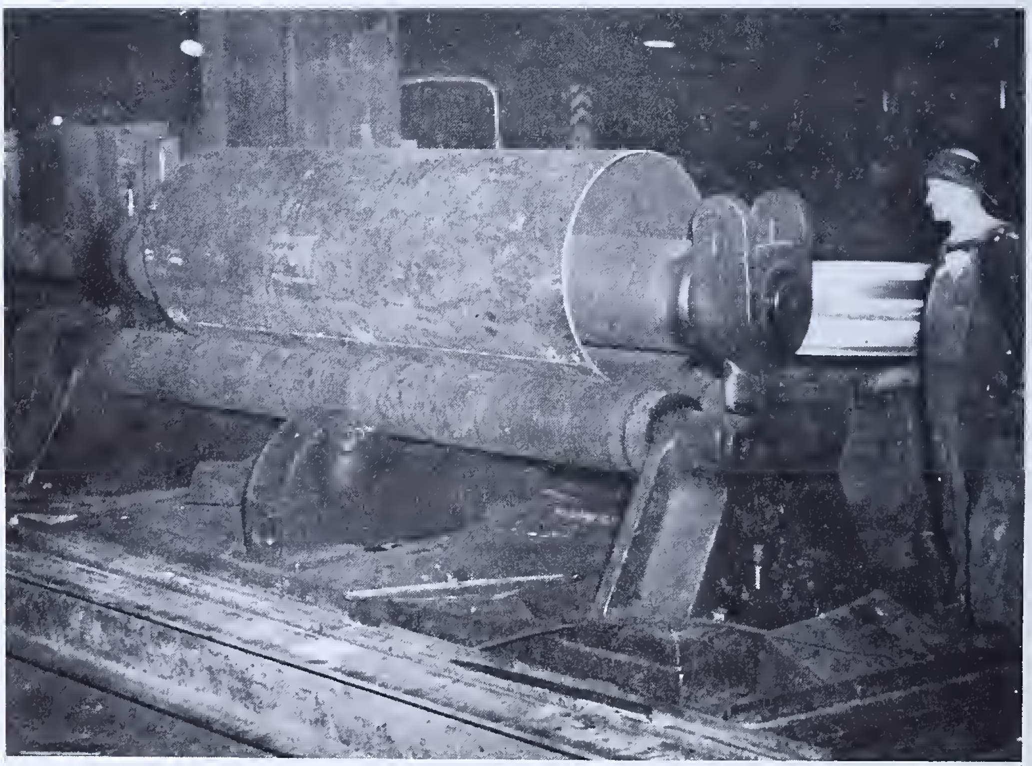


FIG. 140 — *Horizontal Bending Roll — Capacity, 12′ Long*

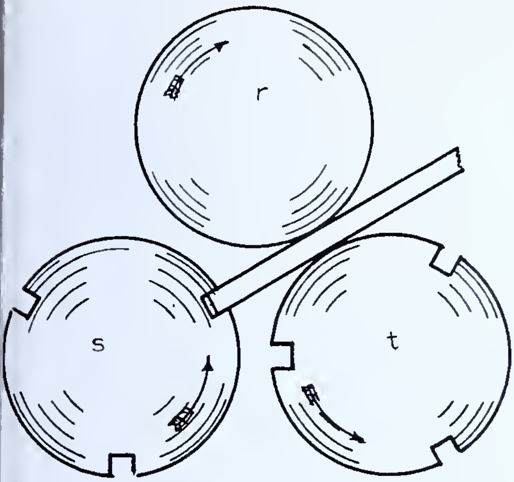


Fig. 141 — *Starting a Plate without First Curving the Edge*

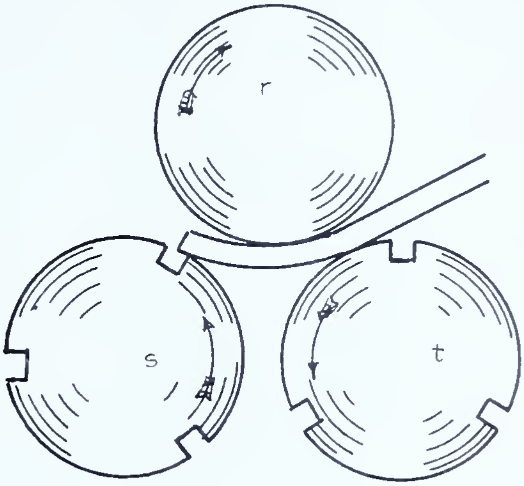


Fig. 142 — *Starting a Plate with a Curved Edge*

Making Preparations for Rolling the Plate

Plates are put through the rolls cold. Heating the plates would require a large heating furnace, and the temperature would have to be kept uniform which in many cases would be difficult. There would be considerable difficulty in handling large. hot plates and considerable danger of severe burns to workmen.

The arrangement of the rolls is shown in Fig. 141 and Fig. 142. The position of the top rolls *r* may be changed in a vertical direction. When a small cylinder is to be formed, the top roll is brought closer to the two bottom rolls *s* and *t*. The notches in rolls *s* and *t* are for the purpose of "starting" the plate through the roll. The plate is shown with its edge in one of the notches in roller *s*, Fig. 141. If the plates were allowed to go through the rolls as shown in Fig. 141 the rolled shape would look like Fig. 143.

Notice that the ends of the plate do not meet after they are rolled. There is a flat spot the entire width of the plate on the edge that entered the roll. Before the flat plate enters the rolls, it must be formed to a curve at the end to prevent this flat spot.

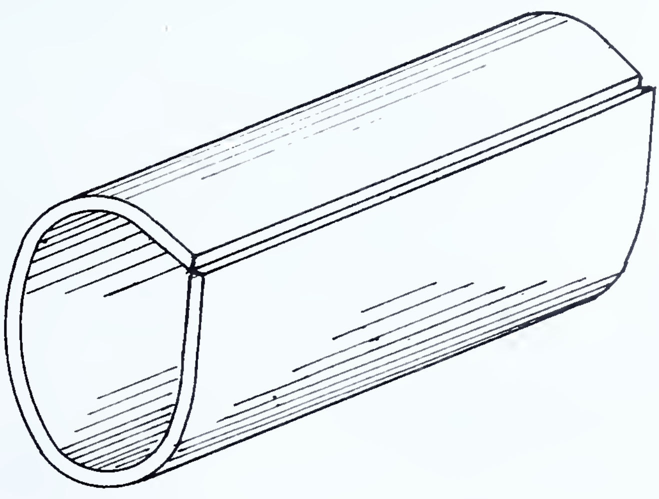


Fig. 143 — *A Flat on the Plate End After Rolling without Bending the Entering Edge*

Preparing the Edge by Bending

There are two ways in which the edge of the plate may be

curved before entering it in the rolls. The edge of the plate may be bent over by using a sledge, or it may be bent in a flanging machine equipped with a male and female radius die. The action of the flanging machine is shown in Fig. 144. The dies are interchangeable so that any desired curve can be formed on the end of the plate. The curve thus formed is the same as the curve which will be produced by the rolls when the entire plate is passed through.

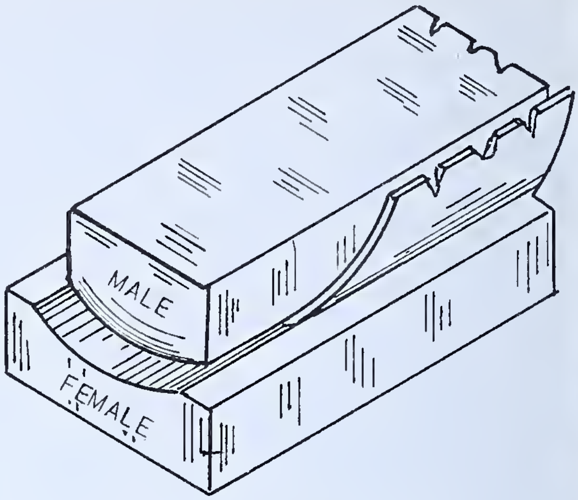


Fig. 144 — *Radius Die*

ROLLING A CORRECTLY PREPARED PLATE

When the edge of the plate has been prepared in the radius die, it can be started in the rolls as shown in Fig. 142. Now the plate will follow the curve and come out of the rolls without any flat spots on the end as shown in Fig. 143.

As the plate passes through the rolls, the curve is frequently checked with a metal sweep or radius gauge. A radius gauge is formed to the exact curve to which the inside diameter of the cylinder is to be rolled. Select the radius gauge carefully to make certain it is the right one for the job.

TO BEND LIGHT SHEET TO A SMALL RADIUS

It is often necessary to bend a round corner in a light plate. Since the radius will be smaller than the radius of the roll, special equipment is used to perform this operation. A casting, which fits to the upper roll *r* and which has the bottom side shaped to the required radius, is fastened to the upper roll by suitable clamps. The plate is then passed through the rolls and allowed to lie on top of *s* and *t* as shown by dotted lines in Fig. 146. The upper roll *r* is then forced down until the required shape is formed around the special attachment.

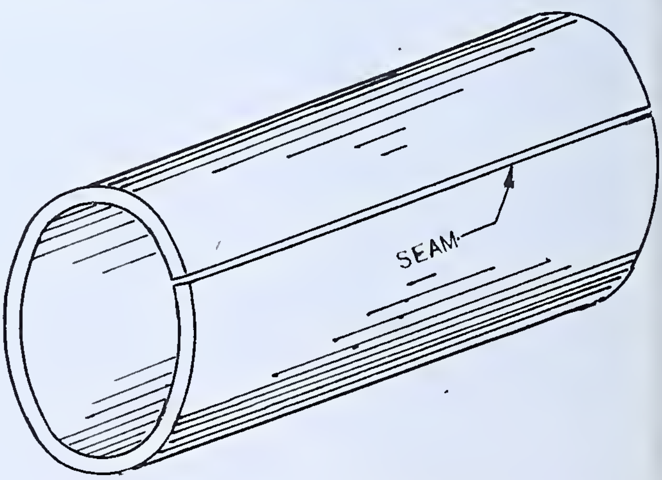


Fig. 145 — *Rolled After the Edge is Bent to a Curve in a Radius Die*

Sometimes a very small radius is to be formed on a light plate.

It is possible to place the plate between two angles as shown in Fig. 147. The upper roll *r* is then forced down until the plate is formed as required.

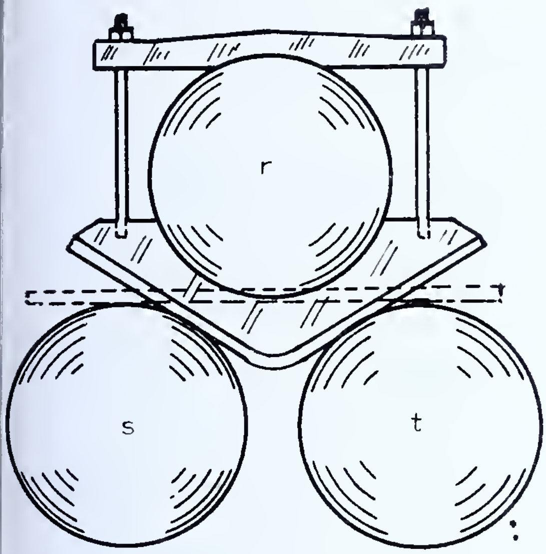


FIG. 146 — *Bending a Round Corner in a Light Plate*

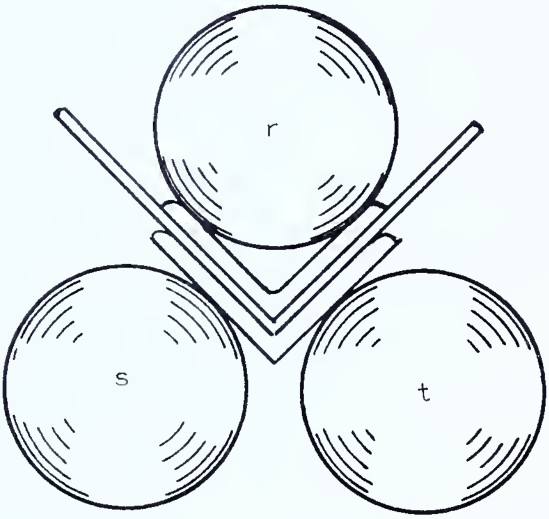


FIG. 147 — *Bending a Very Small Radius*

Rolling the Cylinder

The plates to be rolled are brought to the rolls with a crane. The correct methods of lifting plates, cylinders, and other fabricated pieces of work are explained in Information Sheet No. 4, Handling Materials. Some plates may be light enough that the roll operator and his helper can pick them up manually. Usually the services of the crane are required, and since its use assures greater safety, it should always be called for these jobs.

Tools and Equipment

1. Steel scale
2. Steel sweep

All other necessary tools are usually found at the location of the rolls

Materials

The plate or plates to be rolled

Procedure

1. Turn the plate so that the entering end is toward the rolls and the inside surface up.
2. Pick up the plate by the end farthest from the rolls, and raise it high enough for the entering end to be placed in the rolls.
3. Lower the outer end to about level.
4. Align one of the center lines on the plate with the edge of the groove in the bottom roll.

   If this is not done, the plate will not start through the rolls "fair".

5. Bring the top roll down on the plate until the pressure is sufficient to put a slight bend in the plate. Pressure is applied through a power-operated clutch (Fig. 139) and a geared mechanism.

   Experience soon accustoms the operator to use the correct amount of pressure.

6. Start the rolls slowly and bend the plate.

7. Continue the rolling operation, and at each pass lower the top roll slightly.

8. Check the curve with the steel sweep as the plate approaches the shape required.

9. Continue passing the work back and forth until the ends butt together. The rolling of the cylinder is now completed.

   Never roll a cylinder often enough for the ends to overlap. To do so will cause the diameter to be small. It is a very expensive job to bring a cylinder back to the correct diameter.

10. Raise the top roll to the limit, which will allow the "straps" to "break". See Fig. 140.

11. Remove the locking key in the drop-head and "break" the straps outwardly to permit passage of the rolled cylinder.

12. Have the crane hook on the cylinder and then remove it from the roll.

13. Swing the "straps" back to place, lower the top roll, replace the locking key, and proceed to roll the next cylinder.

QUESTIONS

1. What determines whether a plate is to be rolled to form a full cylinder or a part of a cylinder?

2. Which end of a correctly prepared flat plate should be entered in the rolls?

3. How is the entering end of a flat plate prepared for entering the rolls so that the rolled ends will meet evenly?

4. Which one of the three rolls may be raised or lowered?

5. Explain how this roll is raised or lowered.

6. What is the relationship of the top roll to the two lower rolls when the rolling of the plate is begun?

7. How many passes are usually required for the rolling of a full cylinder?

8. What is the result if an attempt is made to give the plate too much bend in a single pass?

9. What is a sweep?

10. For what purpose is a sweep used?

11. What determines that the rolling of a cylinder is completed?

12. Explain how a completed cylinder is removed from the rolls.

MACHINE OPERATION NO. 2
HYDRAULIC SECTIONAL FLANGE PRESS

General Information

A flange press (Fig. 148) can be used to make sharp bends in heavy steel plates, beams, and angles. Round steel rods up to 3″ diameter can be upset (squeezed to a shorter length with an accompanying increase in diameter) and the ends of steel tubes (stay tubes) can be upset.

Such a machine must be heavy, strongly constructed, and have tremendous power to be effective in its operation. To be universally adaptable to a wide variety of work the machine is built to operate horizontally and vertically. See Fig. 148 for a view from the operator's side of a horizontal sectional flange press.

Fig. 148 — *Flange Press*

Operating Units

The line drawing (Fig. 149) shows the operating units of the press. The die block can be removed from the press table and another die block substituted. Die blocks are made to suit every job or condition.

The vertical plungers are called the "flatter" and the "plow". The flatter holds the work solidly on the die block. See Fig. 150. Since only a section of the work is formed at each descending stroke of the plow, the machine is called a sectional flange press.

After the flatter has been forced down solidly on the work the plow is set in motion (Fig. 151) and a section of the work is forced to the contour of the die block. The plow is then raised and the horizontal plunger (Fig. 152) *p* is forced forward to "set" the bent section against the die block. The horizontal plunger is then drawn

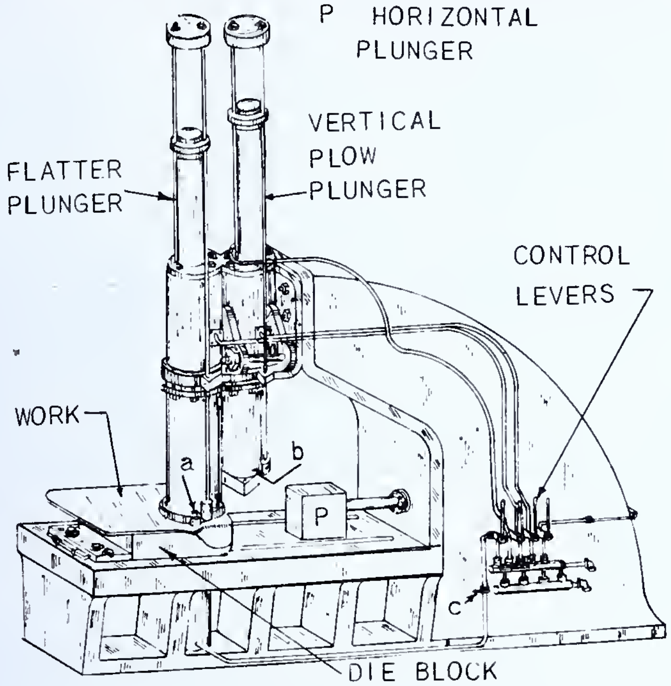


FIG. 149 — *Hydraulic Sectional Flange Press Showing Controls*

back, the flatter is raised, the work is turned to the next position on the die block and the sequence of operations is repeated until the work has been revolved to the starting point.

HEATING THE WORK

Light steel plates can be bent cold but it is customary to heat the steel plate to a bright cherry red before bending it. A heated plate is not apt to "spring back" after the pressure is removed. The work is heated at suitable intervals as the bending proceeds.

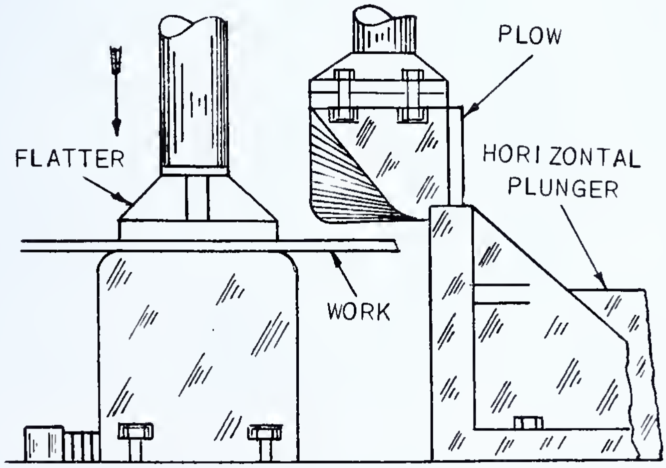


FIG. 150 — *Flatter Holding the Plate to the Bolster While the Plow Descends*

Interchangeable Dies

It will be noted that the plow plunger or the flatter plunger can be equipped with any shape of die (or nose) that is suitable for the work to be done. The horizontal plunger also can be equipped with any shape of die to suit the contour of the die block.

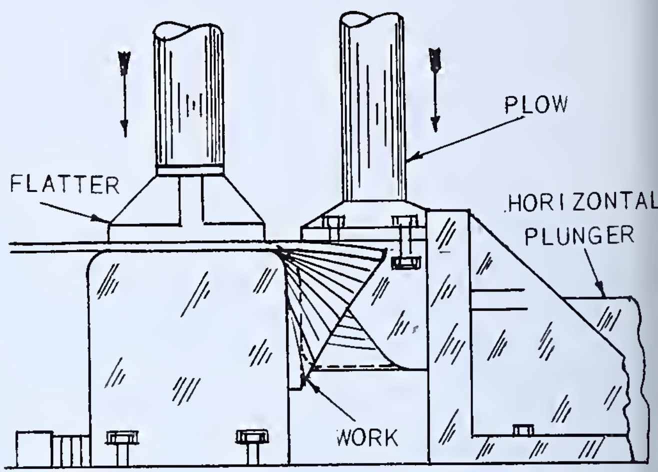


Fig. 151 — *Bending One Section of the Work*

Variety of Work

Any required size of 90° bend can be formed by the use of a special top vee block. The vee block may have a radius to produce a corner from 1/8″ up to 1½″ in the heel of the flange. A radius bar is shown in Fig. 153, tack welded to a special flatter end on the plunger. The plate is placed on the vee block and when the plunger descends the radius is formed on the edge of the plate as shown in Fig. 154.

The plunger action should be controlled in a manner that will allow the bending to begin slowly and then increase as the work takes shape. Caution must be used to release the pressure at the correct point, that is, when the full stroke has been completed.

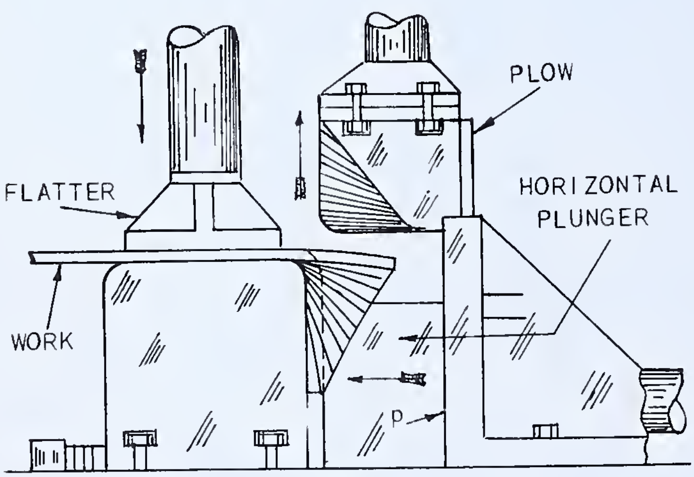


Fig. 152 — *The Horizontal Plunger "Setting" the Work to the Bolster*

Fig. 153 — *First Position for Forming a 1½″ Radius Bend*

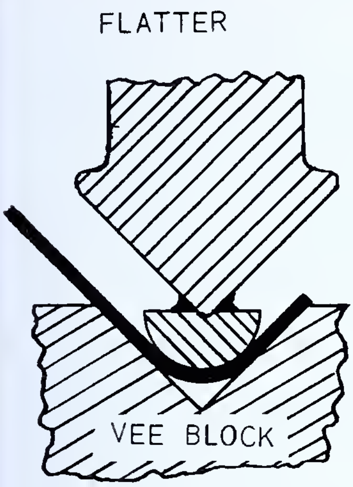


FIG. 154 — *Radius Bend Completed*

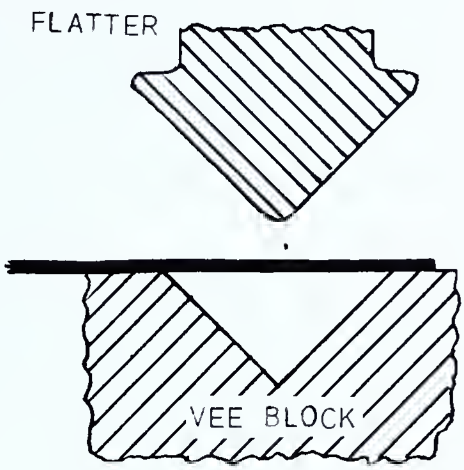


FIG. 155 — *First Position for Forming Small Corner Radius*

A 1/8″ corner radius is shown on the flatter-plunger die in Fig. 155. The vee block is not rounded in the bottom because the metal plate will follow the shape of the nose on the plunger. The completed bend is shown in Fig. 156.

The long end of the plate is supported by hand if the work is light and short. Long, heavy plates are supported by the crane hook which is attached to the plate by means of an automatic plate lifting grab or other suitable clamping device.

With the use of special equipment (Fig. 161) any flat head up to 16′-0″ in diameter and up to 1½″ in thickness may be flanged. The plate is of course heated as the work proceeds.

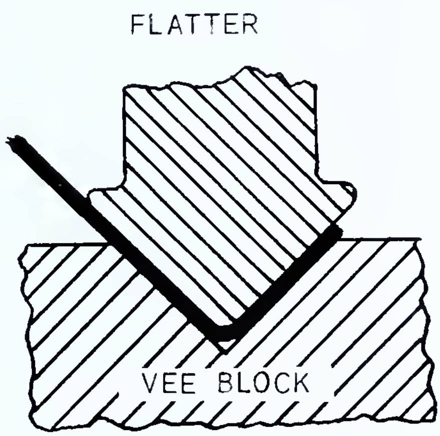


FIG. 156 — *Completed 1/8″ Bend*

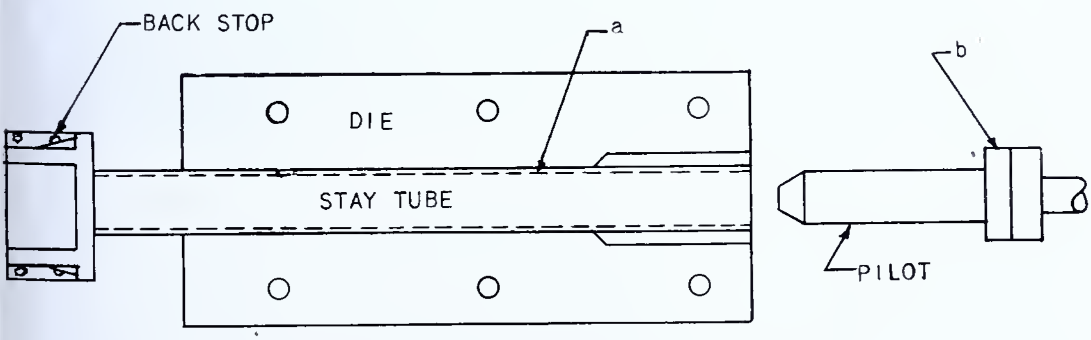


FIG. 157 — *Stay Tube About to be Up-set*

Up-Setting a Stay Tube End

Stay tubes are made from seamless steel tubing and before they can be threade on the ends they must be up-set. A stay tube with the ends threaded is shown in Fig 418, Job Sheet No. 8. The stay tube *a* is placed in the bottom die, a plan view o

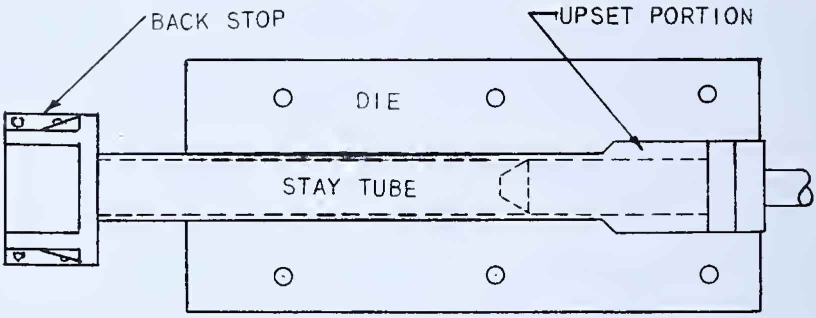


Fig. 158 — *Stay Tube After Up-setting*

which is shown in Fig. 157. The pilot is securely bolted to the horizontal plunge: The dies are opened, the heated stay tubes are placed in position with one end butte against a stop, the dies are closed, and the pilot is moved forward to up-set the en of the stay tube. A plan view of the bottom die, the stay tube, and the pilot is show in Fig. 158 at the end of the up-setting operation.

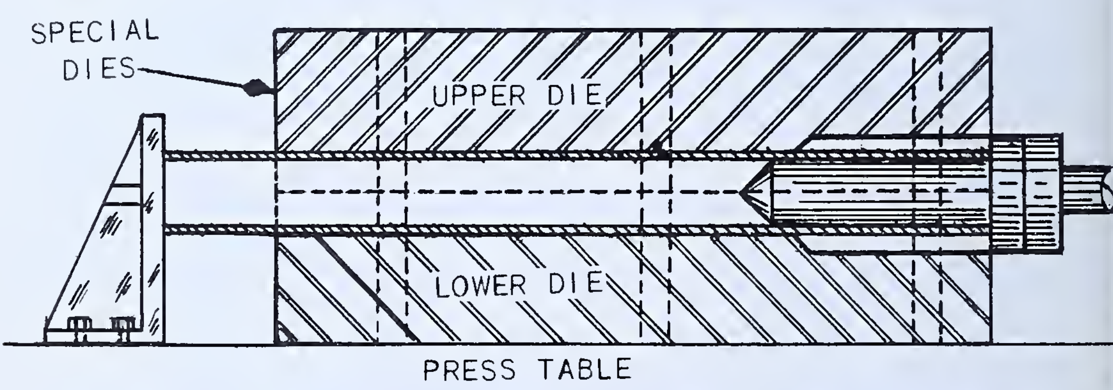


Fig. 159 — *Cross Section of Stay Tube Held in Dies for Up-setting*

The ends of stay tubes are up-set in special dies secured to the flange press tabl as shown in Fig. 159. The stay tube is shown in Fig. 160 after it has been up-s and removed from the die. To up-set the opposite end of the stay tube it is necessar to replace the dies just used with another set of dies of the proper shape and diamete Before the stay tube is placed in the die to be up-set it is heated as far as point *a* in Fig. 157. Before it has had a chance to cool, the dies are quickly closed and the pilot is forced into the hole in the stay tube

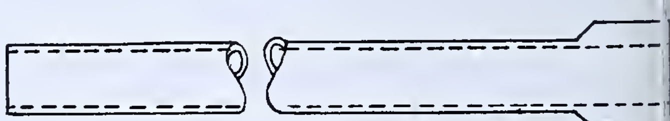


Fig. 160 — *Stay Tube After the Up-setting Operation*

or the correct distance. The collar *b* shown on the pilot in Fig. 157 is easily removable so that when it becomes overheated it can be replaced with another collar. If this replacement were not made the diameter of the collar would be sufficiently enlarged by the heat to cause it to stick in the die. Removing the hot collar and replacing it with a cool one permits the up-setting operation to continue without interruption.

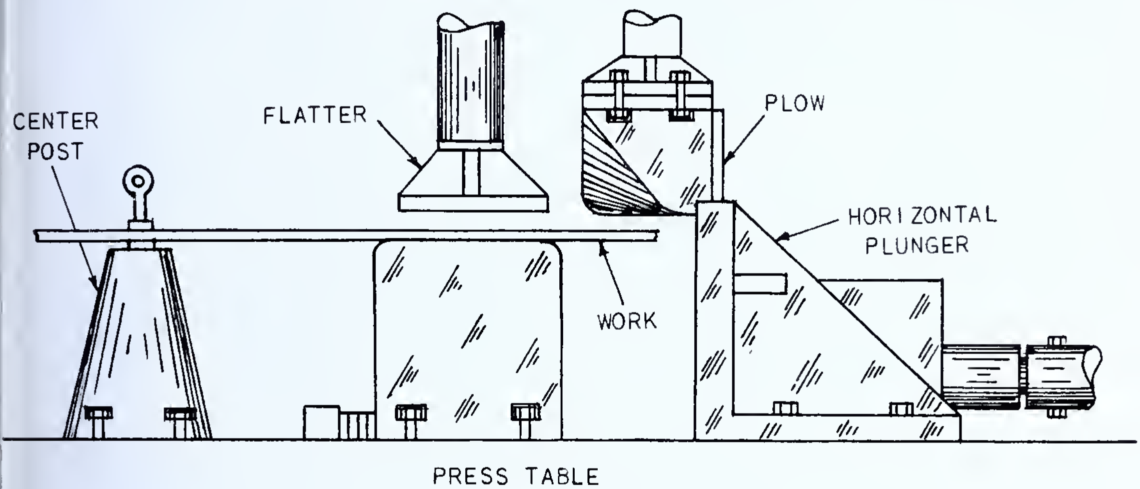


Fig. 161 — *Flanging a Flat Head*

Flanging a Flat Head

The center post shown in Fig. 161 is bolted to the press bed plate and acts as a center around which the flat head is revolved as it is flanged. The shims are carefully adjusted so the die will remain securely anchored. There must be no change in the distance between the center of the center post and the working side of the die or the flat head will not be round nor will it be the same diameter at all points.

The vertical flatter can be used to straighten any plates that have become buckled. Also propeller blades that have become damaged can be brought back to the correct shape with the vertical flatter when the flatter plunger has been fitted with suitable dies.

When stay rods, and the ends of stay tubes have to be up-set, the horizontal plunger is equipped with suitable dies for the job.

Capacity of the Flange Press and Power Source

Each plunger is capable of exerting a pressure of 150 tons. The power is obtained from a hydraulic accumulator (an electrically operated water pump). By means of suitable valves the pump forces water into the plunger cylinders and the water forces the plunger out of the cylinder.

When it is desired to move the plunger in the opposite direction the operator reverses the flow of the water by manipulating the control levers shown in Fig. 149. Any liquid system for applying power is called a hydraulic system. The operation of this water system is practically the same as that found in any hydraulic automobile brake system. The flange press could be operated with a hand-pumped hydraulic

system but the electrically operated system performs the work in a fraction of the time required for hand operation.

Draining the Hydraulic System

During freezing weather the hydraulic cylinders and valve-control piping must be drained to prevent damage from frost in the lines and in the cylinders. Cracked cylinders or burst pipes could render the flange press useless for days or even weeks since repair parts are not easily available at all times.

Drain plugs (Fig. 162) are provided at the base of the cylinders for the purpose of draining the water. When the flange press is not in use during freezing weather, the drain cocks should be opened and the water should be drained thoroughly. Three drain cocks are shown in Fig. 149, at *a*, *b*, and *c*. There is another drain cock hidden from view on the opposite side of the machine. Since the drain cocks on these machines are not always found in the same locations, the operator should use caution and see that every drain cock is opened before the machine is left to stand idle for any length of time.

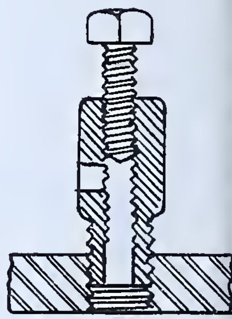


Fig. 162 — *Drain Cock Shown at* a, b *and* c *in Fig.* 149

Tools and Equipment	Materials
1. Trammel points and stick	Suitable die block
2. Homemade square fastened to a stick	Wedges
3. Straight-jaw tongs	Bolts and straps
4. 90° bent-jaw tongs	Flange gauge
5. Large flange fire	A good grade of pulverized soft coal
6. Templates and sweep	48 hour coke
7. Plate-lifting grabs	Water hose
8. 2 — 12-lb. sledges	Piece of wood or 1/4″ steel plates for the fire
9. Long steel hoe and hook	
10. Folding rule	
11. 1 1/4″ open-end wrenches	
12. Pinch bar	

The work involved in operating a flange press for the purpose of forming a flange on a flat head or for the purpose of forming similar shapes may be summarized as follows:

Procedure

1. Obtain the correct dies, flatter, and plow for the job and fasten them securely in their proper position.

2. Obtain the flat-head blank on which the flange is to be formed.

3. Set the center post at the correct blueprint location on the press bed and fasten it securely in place.

4. Measure from the center of the center post to the forming side of the die and check the dimension with the blueprint. (Adjust the post setting if necessary.)

5. Fasten the eye bolt securely in the pilot hole. (The eye bolt provides a center around which the flat head turns and keeps the flange uniformly distant from the center.) The hole in the eye bolt is for the purpose of picking up the flat head quickly with the crane. The crane hook is inserted into the eye.

6. Pick up the flat head with the crane and place it in position on the center post and on the die.

7. Manipulate the control valve to cause the flatter plunger to descend to force the work tightly to the die.

8. Manipulate the control valve to cause the plow plunger to descend and form the first section of the flange.

9. Manipulate the control valve and cause the plow plunger to return to its original position.

10. Manipulate the control valve and cause the horizontal plunger to force the flange against the die. Return the horizontal plunger to its original position.

11. Release the flatter and turn the work to the next position for flanging.

    Turn the work just far enough so part of the flange previously bent will be in the path of the plow plunger at the next stroke. This procedure will prevent the formation of "wrinkles" in the flange as successive bends are made.

12. Repeat the operations according to the foregoing (steps 7 to 10 inclusive) until the flange is formed around the entire circumference.

13. Lift the flat head from the press.

QUESTIONS

1. Why is this machine called a sectional flange press?

2. How many men are required to operate this machine?

3. Explain the uses of the vertical flatter.

4. State how the plow should be used.

5. Name the types of jobs for which the horizontal plunger is used.

6. Describe the dies used to set the ends of plates to be rolled.

7. When setting the ends of plates to be rolled, how far from the end of the plate should the curve extend?

8. Name a number of jobs that can be formed in this machine.

9. Explain how different radii on plates may be formed with the same size of vee block.

10. Which of the three plungers is used to do most of the work on the flange press?

11. Under what conditions is it possible to form cold plates in the vee block on the flange press?

12. Explain what plungers are used to up-set the ends of stay tubes.

13. Describe radius blocks and dies.

14. What particular precautions should be taken to prevent flange press trouble in freezing weather?

15. Explain how the cylinders of a sectional flange press are drained.

MACHINE OPERATION NO. 3
HYDRAULIC RIVETER

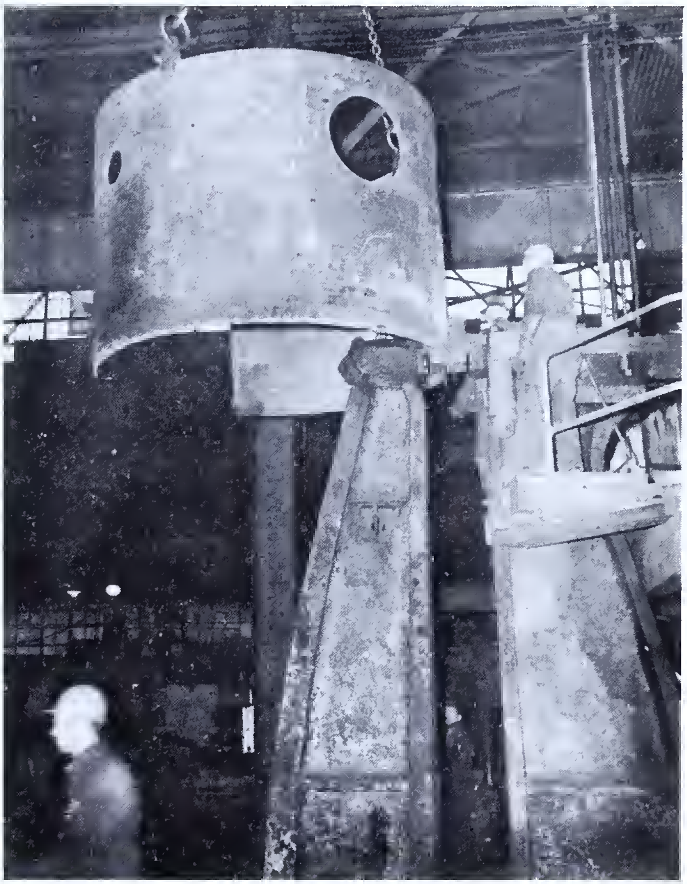


Fig. 163 — *Hydraulic Riveter — 150 Ton Capacity*

General Information

Tanks, drums, scotch boiler shells, and, stack plates, and plate ends can be "set" on this machine. The ends of plates can be "set" in the keel bender or in the hydraulic flange press up to certain lengths and thicknesses. Exceptionally long and thin plates are "set" in the hydraulic riveter.

The plates are handled by the crane (Fig. 164) and suspended in a vertical. position to bring the plate to the correct location between the setting dies which are held in the yoke of the machine as shown in Fig. 163.

The yoke, Fig. 165, is a steel casting with a fourteen-foot throat. One die is secured to the nose on the stake side of the yoke as shown in Fig. 165. The other die is secured to a ram on the opposite side of the yoke. The female die is actuated by hydraulic pressure controlled by a valve. Figure 163 shows the operator and the helper working on a cylindrical shell to straighten the curve. The male and female dies can be reversed if conditions make it necessary.

A front view of the nose and the male die is shown in Fig. 169.

The female die is shown in Fig. 167. The nose and the ram have two-inch holes bored in their centers for the purpose of receiving the stems of the male and female dies. These holes are shown in Figs. 169 and 170.

The dies are free to turn on the stems so that they can be adjusted quickly to fit the contour of any work that is placed between them.

A cross section of the upper end of the stake showing the nose and the upper end of the yoke opposite the nose, is shown in Fig. 167. Note the ram position opposite the nose. Both male and female dies are equipped with stems which fit into suitable holes. The operator can adjust the position of the dies, to meet the curve of the work, by merely turning the dies in either direction. Since the stems are the same size the dies are readily interchangeable when conditions demand it.

The relationship of the two dies is clearly shown in Fig. 170. The cylindrical shape shown in Fig. 163 can be passed between the dies and formed to the die shape. Flat plates also can be passed through other dies and can be straightened, set on the ends, or bent at any point desired.

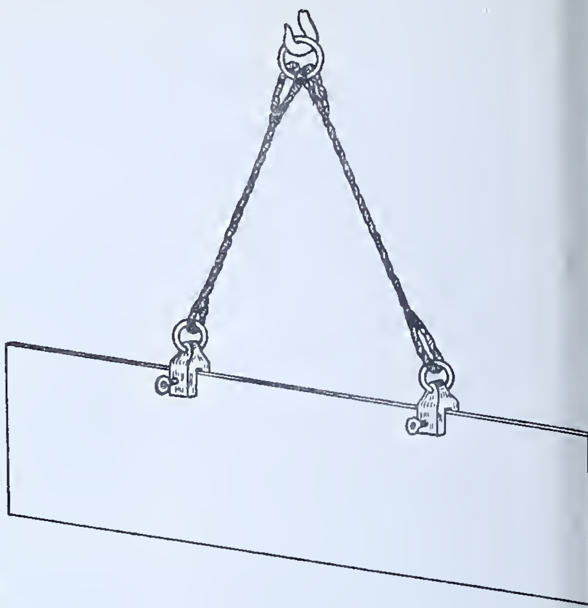


Fig. 164 — *Handling Plates with a Crane*

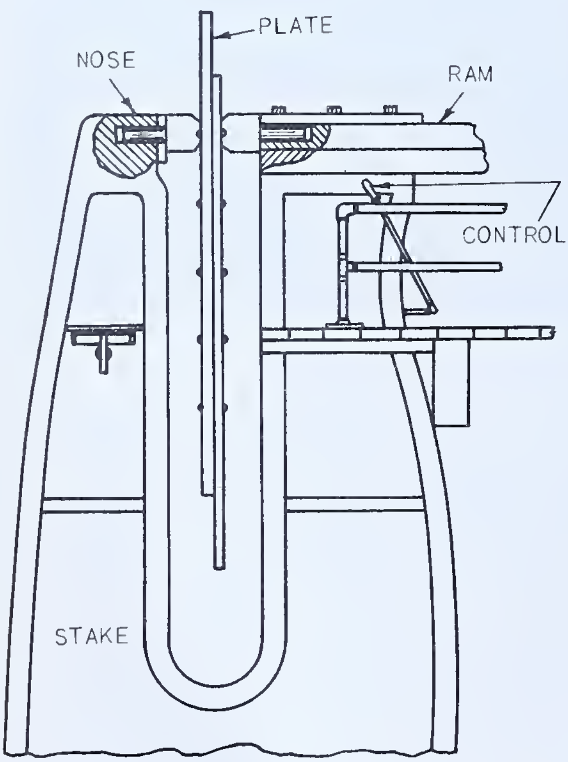


Fig. 165 — *Hydraulic Riveter with Plate Between Jaws*

Dies can be changed as often as the job requires. When the "set" (curve) in the ends of the plates closely approximates the curve of the dies already in the machine a special pair of straps shown in Fig. 171 is adjusted to hang over the face of the female die. This arrangement provides a means to set the plates to a sharper radius without changing dies. This strap arrangement takes the place of shims which are used in the flange press and in the keel bender.

The strap arrangement is shown in Fig. 172. There are several different thicknesses of straps to take care of various conditions as they arise. The straps are usually 2″ wide but they can be made any thickness required to suit the job.

Fairing a Welded Seam

When plates ends have been set carelessly and the curve is either too much or too little the condition can be corrected after the seam has been welded. When the plate has been set too much the welded job will appear as shown in Fig. 173. The plate ends often become distorted when the seam is welded. This condition can be corrected in the same manner as explained in Figs. 173 and 174.

When the plate has not been set enough the welded job will appear as shown in Fig. 174.

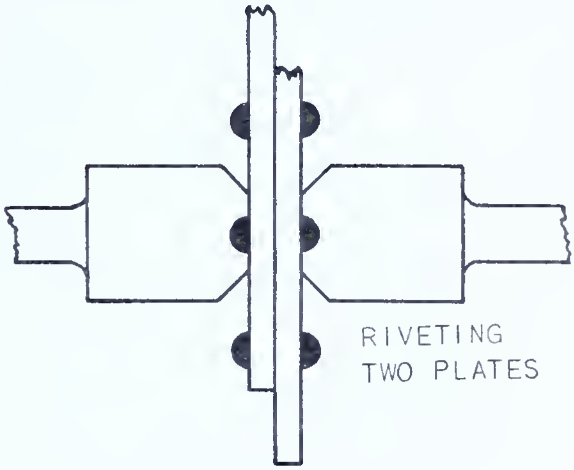


Fig. 166 — *Enlarged View of Dies Shown in Fig. 165*

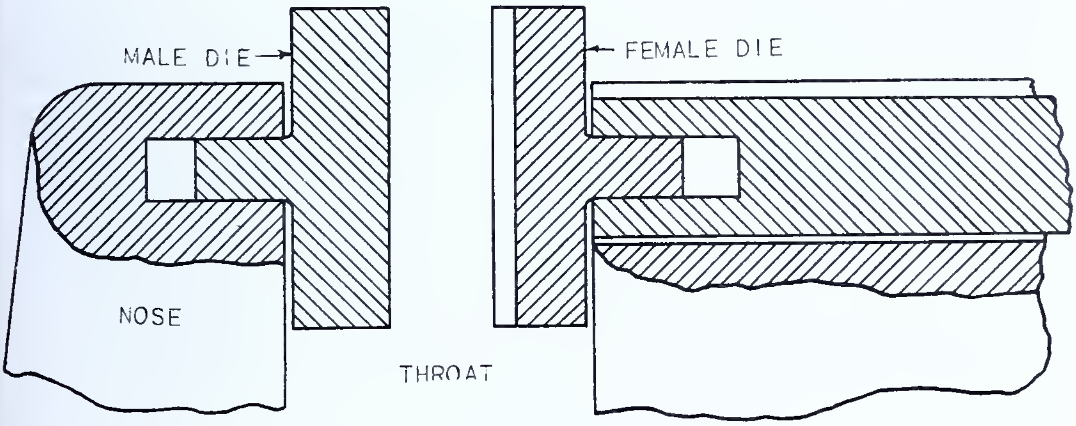


Fig. 167 — *Cross Section of Nose and Ram*

The operations necessary to fair the seam in the machine are clearly shown. It may be necessary to use straps at certain locations on the dies.

The work involved when operating a hydraulic riveter to set the ends of a plate may be summarized as follows:

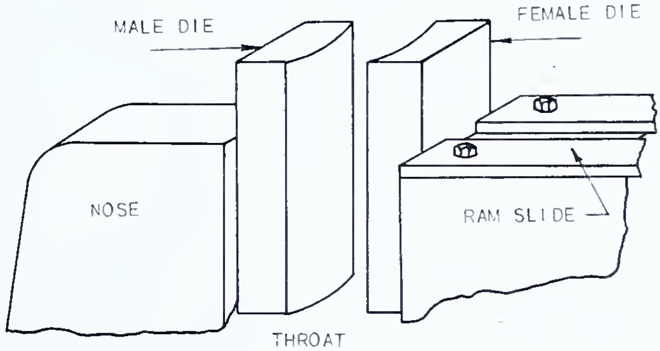


Fig. 168 — *Male and Female Dies*

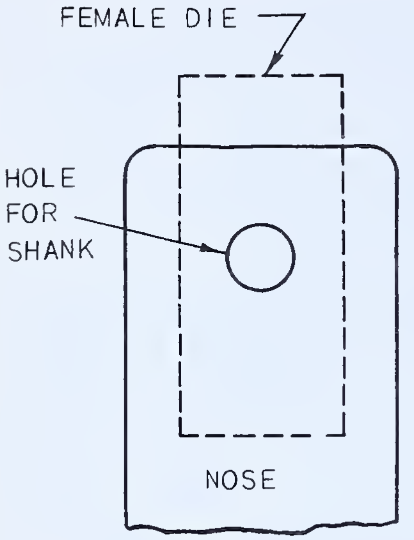


Fig. 169 — *Nose Side of Yoke*

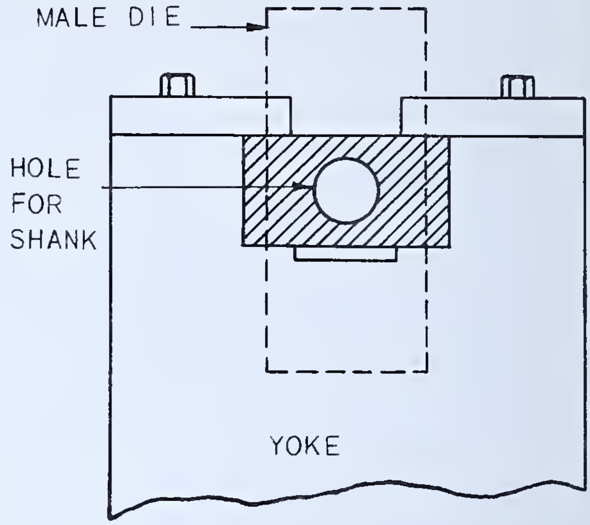


Fig. 170 — *Side Opposite Nose*

Tools and Equipment

1. 2 Plate-lifting dogs
2. Sweeps
3. Rule
4. 10-lb. sledge
5. Set of cable hooks
6. 1¼″ x5′ pinch bar

Procedure

1. Lay off the location for the lifting dogs.

   Find the center of the plate and locate the dogs at a distance apart which is equal to 1/3 the length of the plate (Fig. 164).

2. Apply the lifting dogs to the plate as shown in Fig. 175.

   Note the position of the dog in relation to the edge of the plate. If the dog is not applied so that the edge of the plate will clear the round corner in the dog the plate will slip out. Be sure that the screw is se-

Fig. 171 — *Straps and Female Die*

Fig. 172 — *Strap Arrangement*

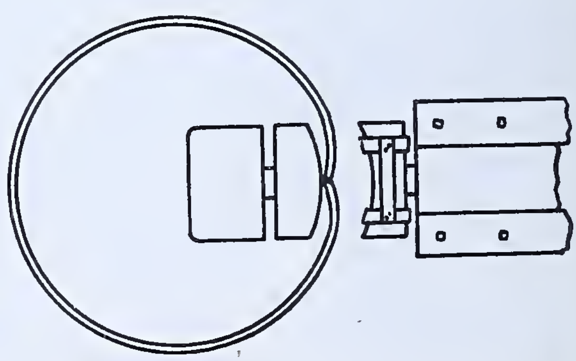


Fig. 173 — *Setting a Cylinder That Has Been Rolled "Too Quick"*

curely tightened on the work. Never trust others to tighten a dog. Test it thoroughly before proceeding with the job.

Use a good set of cable hooks with a cable long enough that will not draw the dogs in on the plate and cause the dogs to loosen.

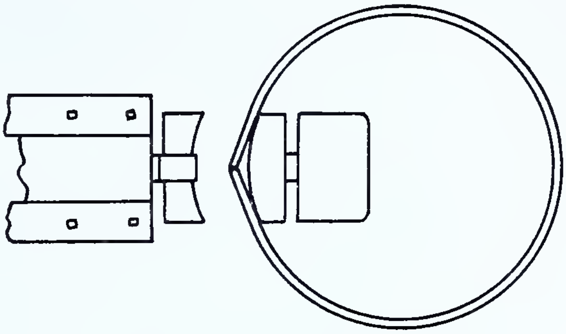


FIG. 174 — *Setting a Cylinder That Has Not Been Rolled "Quick Enough"*

3. Signal the crane to lift the plate into position.

   Make sure the plate is facing the right direction which has been marked on it.

4. Manipulate the controls and cause the ram to make the first impression on the plate.

5. Manipulate the controls and release the ram.

6. Check the set of the plate with the sweep.

   If the curve is correct, proceed; if more or less set is needed, adjust the straps accordingly.

7. Proceed to set the plate the full length.

   After each move of the ram, raise the plate about two-thirds the length of the die and break the next portion of the plate edge.

8. Continue this operation until the first break has been made the width of the plate.

9. Shift the plate about 9″ forward between the dies and beginning at the bottom make the second break.

10. Continue making successive breaks until the plate has been lowered to the bottom position.

11. Check the entire length of the curve with the sweep.

    If there are any places where the set is not correct, the plate can be raised or lowered to the right location and the set can be made to fit the sweep before proceeding farther with the job.

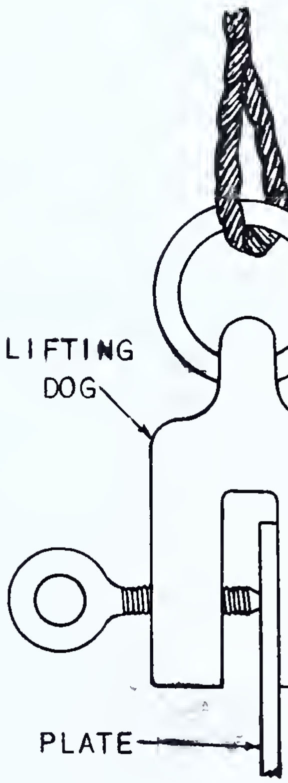


FIG. 175 — *Plate Lifting Dog*

12. Lower the plate to the shop floor and change the lifting dogs to the opposite side.

13. Pick up the plate as in Step 3 and proceed to set the opposite end.

14. Remove the job from the hydraulic riveter and lay it on the floor near the plate-bending rolls.

QUESTIONS

1. Describe the types of work for which the hydraulic riveter is best suited.
2. What sizes of plates do not usually have the ends set in a hydraulic riveter?
3. How is the set taken out of a plate on the hydraulic riveter?
4. Which die is usually located on the "stake" of the hydraulic riveter?
5. When is it necessary to reverse the position of the dies from the stake to the ram and from the ram to the stake?
6. How is the die in the nose of the machine held in place when the machine is in operation?
7. What is the purpose for using shims or "straps" when making bends or sets on this machine?
8. What is the procedure for fairing a welded seam which has been improperly set?
9. State the probable result if the plate dogs are not placed and secured on the plate properly.
10. How tightly should the plate-dog screws be turned?
11. What type of hook should be used for handling plates which are to be worked in this machine?
12. State the reason for using the hooks specified in answer to question No. 11.
13. State the probable result if the lifting hooks have too much spread when attached to a plate.
14. Explain why a mechanic need not be a rigger to handle material in the shop.
15. Who is the official crane-signal man when the hydraulic riveter is in operation?
16. How many breaks are required to set a plate end?
17. Explain the procedure to follow when about to set a plate end in the hydraulic riveter.
18. State the conditions which determine when a plate must be taken to the hydraulic riveter for setting.
19. The pressure exerted on a hydraulic riveter can be adjusted from 75 tons to 150 tons. State the pressure used when bending a light plate.
20. Name several safety precautions which should be observed when operating a hydraulic riveter.

MACHINE OPERATION NO. 4
PLATE PLANER

General Information

Mention has been made in Job Sheets No. 1 and 2, Part VIII, of various plates that have the edges planed before the joints are welded. Planing the edges of plates in this manner insures a straight job and a uniform weld along the seam. Plates of any width and up to 40′ long can be planed on the plate planer. The plate is held down firmly to the table of the machine by pneumatic pistons which may be seen spaced at regular intervals in Fig. 176.

The machine will accommodate any thickness of plate ordinarily found in the boiler shop. Thicknesses of plates usually range from ¼″ up to 2½″.

Operator's Position

The operator stands on a small platform, Figs. 177 and 178, which is suspended from the tool carriage. Since the tool carriage moves along the ways from end to end of the machine, the operator is carried with it. This arrangement makes it possible to inspect the work closely as the cut is taken, and to note immediately the necessity for any adjustment of the plate or the tool.

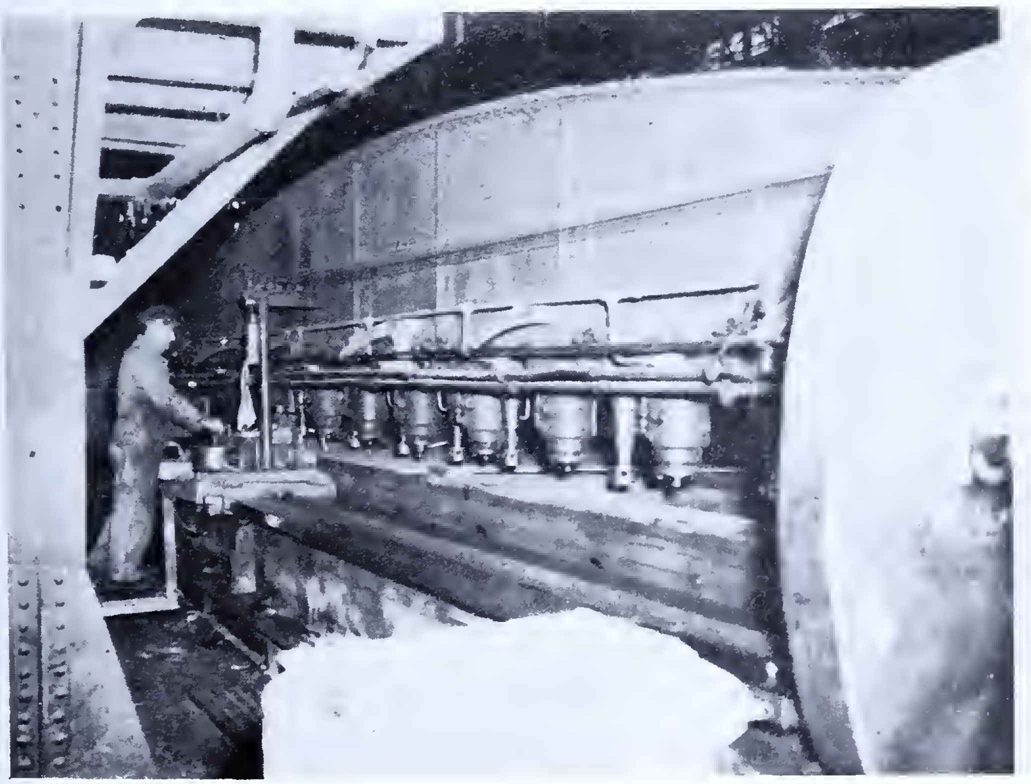


Fig. 176 — *Forty Foot Plate Planer*

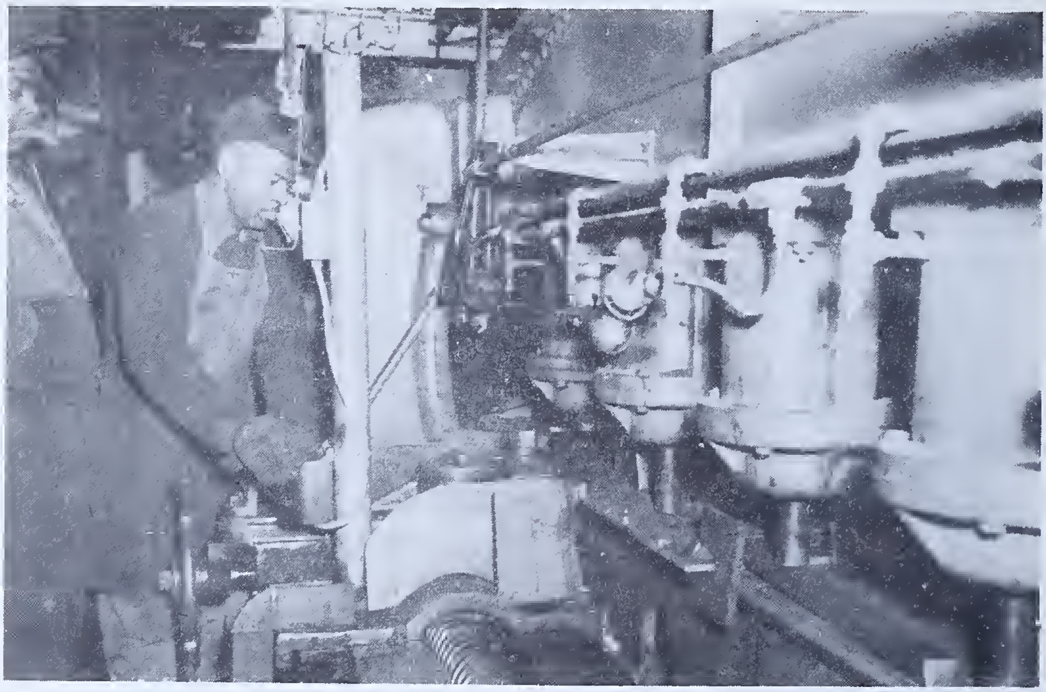


Fig. 177 — *Close-up of Tool Post and Cross Feed*

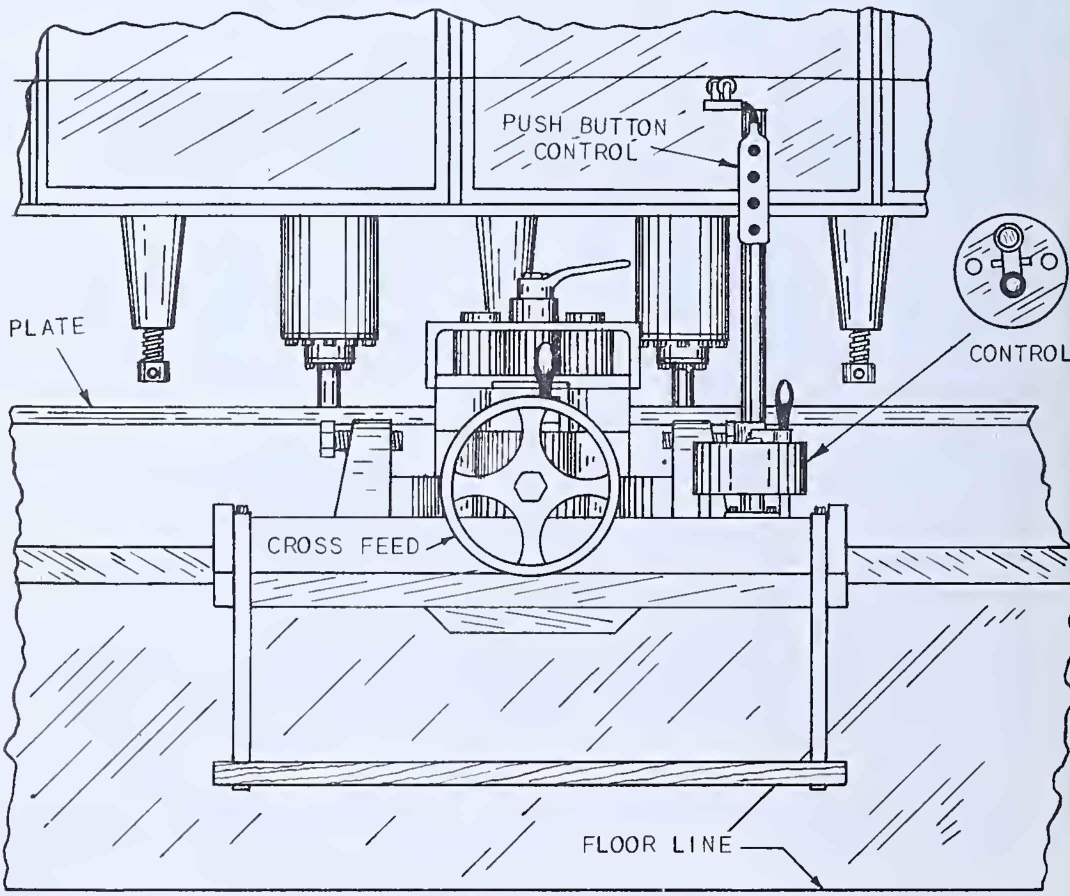


Fig. 178 — *Tool Carriage and Operator's Platform*

Machine Control

A four-button control (Fig. 179) is attached to the tool carriage within easy reach of the operator. If an emergency should arise the motion of the tool carriage can be stopped or reversed immediately. A master switch, installed in a convenient position, can be pulled at any time thus cutting off the electric current while the operator is making adjustments or while he is absent from the machine.

Fig. 179 — *Push Button Control*

Tool Carriage

The tool carriage is propelled by means of a heavy screw along parallel ways. A cross section of the ways and the feed screw is shown in Fig. 180. A tool post is mounted on the carriage and it can be adjusted vertically and horizontally. A close-up view of the tool post and carriages is shown in Fig. 177. It will be noted that the path of the tool is always parallel with the ways. More will be said about this later on in this job sheet.

Cutting Tools

All cutting tools for this machine are made from the same size ($2\frac{1}{2}''$) of square steel stock. The cutting edges of the tools are ground to the shape which will produce the required edge on the plate to be planed. A few of the commonly used shapes of edges are shown in

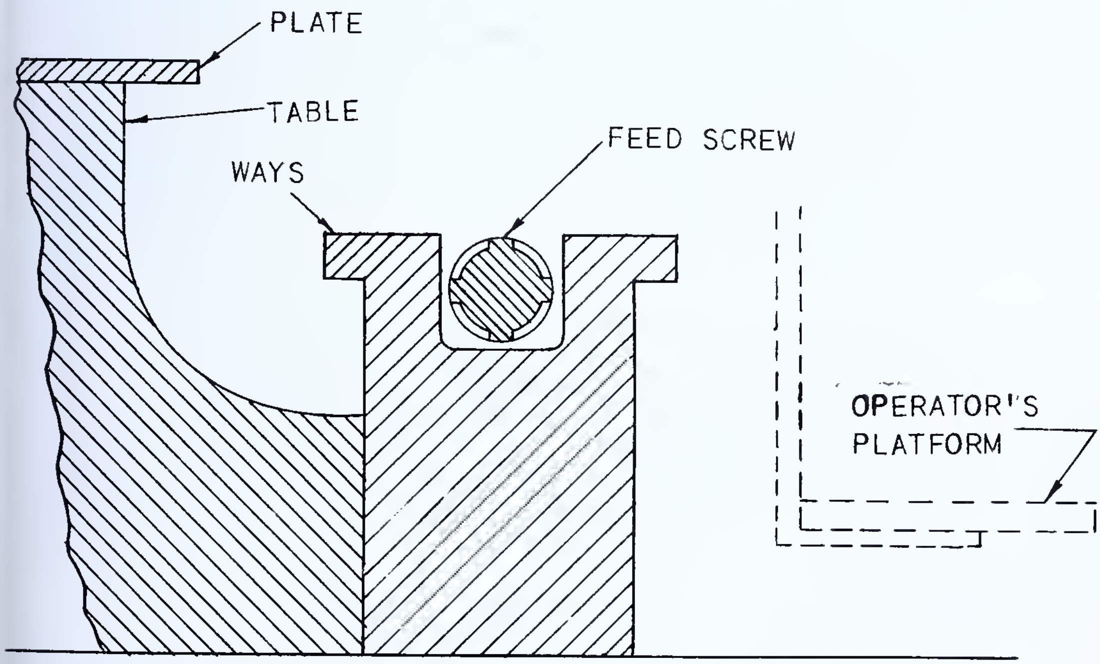


Fig. 180 — *Ways and Feed Screws*

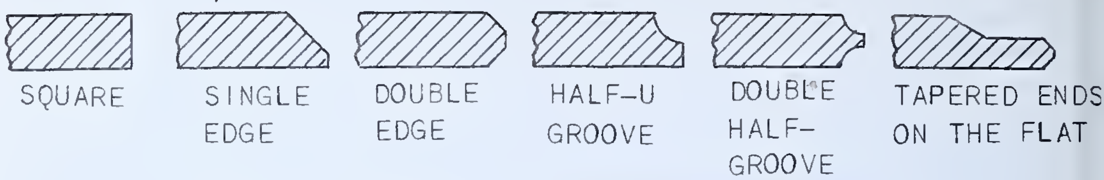


Fig. 181 — *Shapes of Commonly-Planed Edges*

Fig. 181. When once the tools are dressed and ground to the correct shape an occasional touch-up on the emery wheel will keep them in good cutting condition.

Setting the Plate on the Machine

A close-up of the tool post and carriage is shown in Fig. 177. The edge of a plate is shown projecting over the edge of the machine table. A pictorial plan view of the table and ways is shown in Fig. 183.

The work is picked up with the crane and it is laid on the machine table. The edge of the plate is caused to project over the edge of the table about one inch and parallel with the table-side of the ways. It is clamped to the table temporarily while a check is made to find if the working line on the plate is parallel with the side of the ways. A special tool (Fig. 182), is used for this purpose. This tool is shaped like a surface gauge. The base of the tool fits over the table-side of the ways and the pointer is adjusted in the center-punch marks on the working line.

The tool is then placed over the table-side of the ways at the opposite end of the plate and a similar check is made. The plate must be moved in or out until the pointer registers in the center-punch marks at both ends of the plate. The plate is moved in by butting the tool against the edge of the plate and adjusting the cross slide. When the adjustment had been made correctly, the plate is securely clamped to the table in readiness for the edge to be planed.

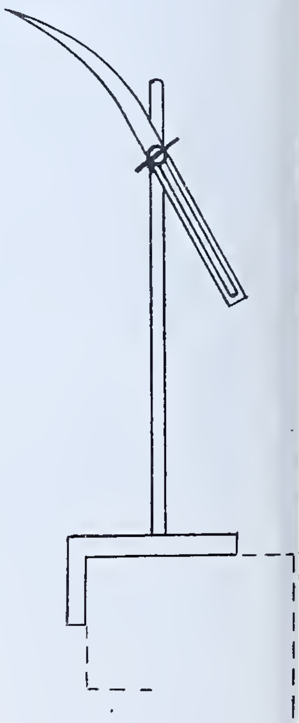


Fig. 182 — *Special Aligning Tool*

Cutting-Tool Action

Typical examples of cutting tools in action are shown in the illustrations immediately following. The tool shown in Fig. 184 is used to plane square edges. Note the three center-punch marks which indicate the line to which the edge of the plate is to be planed. The cutting edge of the tool must split the center-punch marks on center.

The tool shown in Fig. 185 is used to plane a bevel on the edge of a plate but only after the plate has been planed square and to the working line.

The tool shown in Fig. 186 is used to plane a half-U

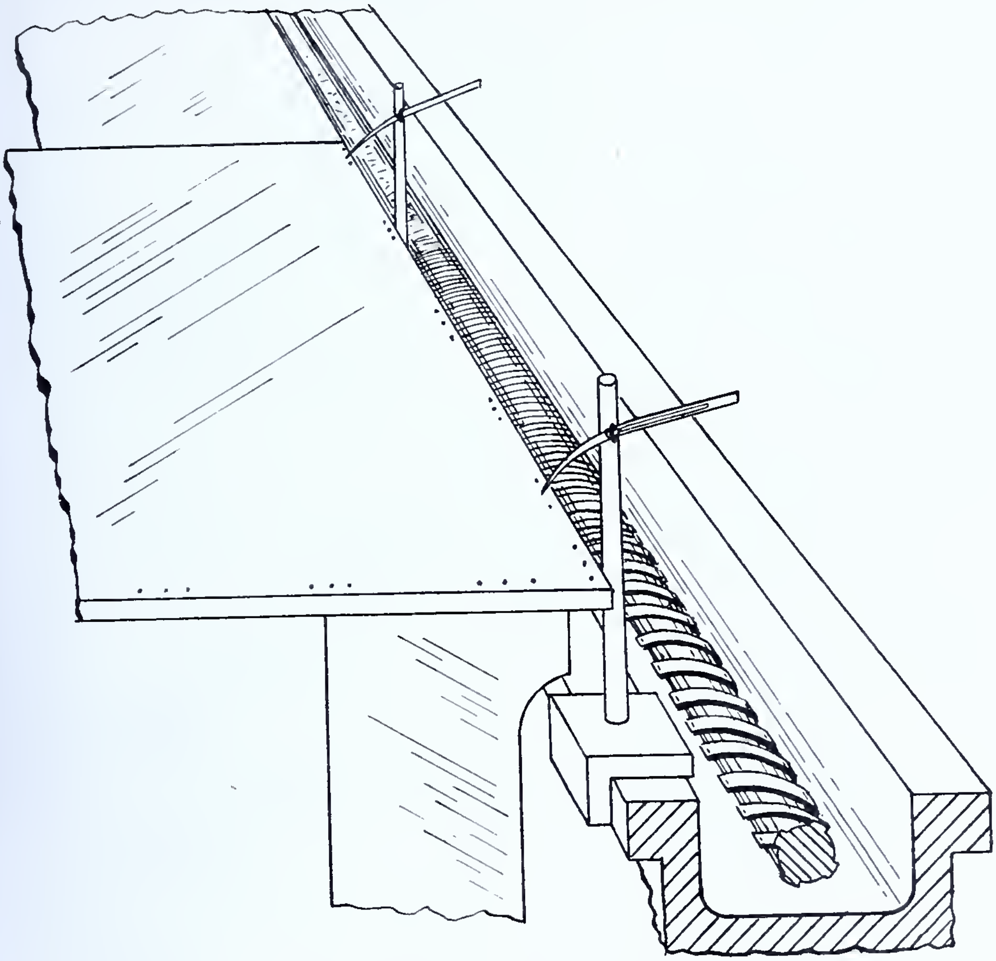


FIG. 183 — *Pictorial Plan View of Table and Ways*

groove in the edge of a plate but only after the plate has been planed square and to the working line.

The tool shown in Fig. 187 is used to plane a combination bevel and flat on the edge of a plate but only after the plate has been planed square and to the working line.

The layout man has a template for every size and shape of commonly planed plate edge. The operator should obtain the correct template for the job and check the cut frequently for size and shape.

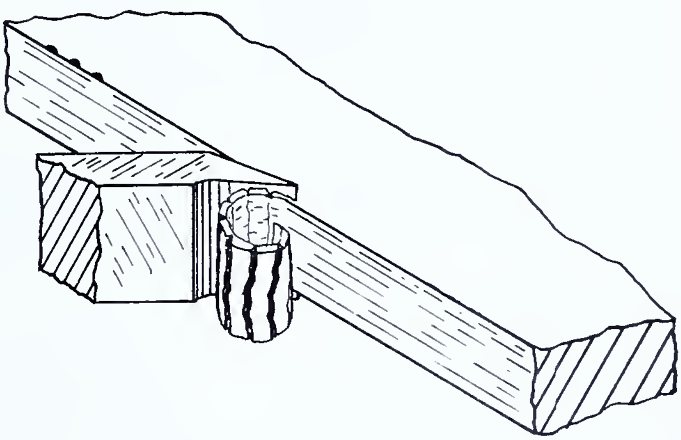


FIG. 184 — *Square-Nose Tool*

Planing on the Under Side of the Plate

The double-edge shape, the double half-groove, and the tapered ends on the flat shapes shown in Fig. 181 are planed on the bottom side while the plate is held to the table at the first setting. In order to accomplish this, the cutting tool is turned over and the tool holder is lowered until the correct cutting position is obtained.

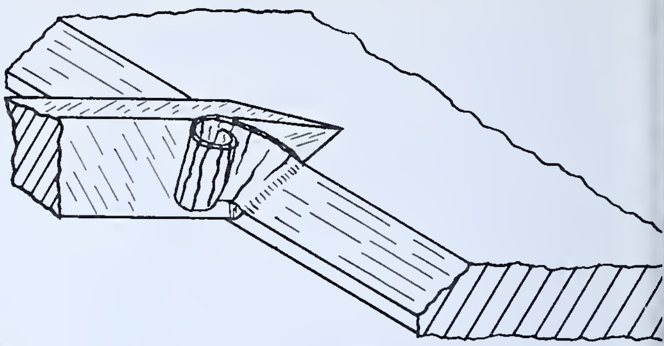


Fig. 185 — *Bevel-Nose Tool*

Planing a Piece Longer Than the Planer

Some plates are longer than the planer but they can be planed by taking two cuts. Plane the edge as far as possible and then shift the work. To make the shift, clamp a dog on the plate near the end of the first cut.

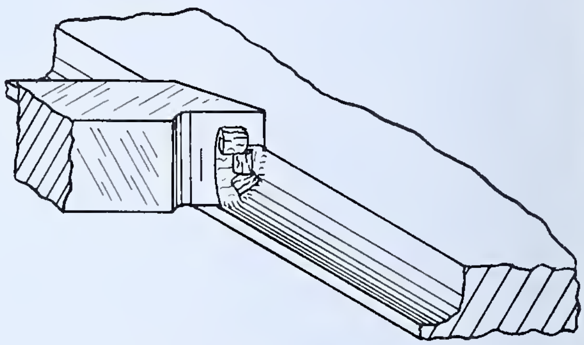


Fig. 186 — *Planing a Half-U Groove for a U Weld*

Have the crane operator hook on to the plate at the rear of the machine. Bring the tool carriage down until the tool will engage behind the dog. Then move both the carriage and the crane in unison and pull the plate along to a new position. Check the alignment of the plate to make certain the next cut will be a true continuation of the first cut.

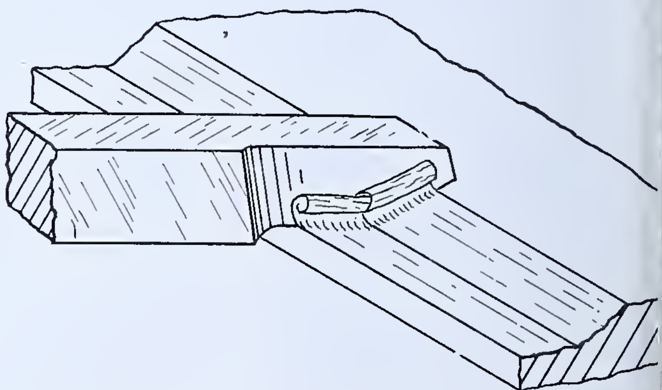


Fig. 187 — *Planing a Combination Bevel and Fl*

Tools and Equipment

1. Gauges
2. Planer tools
3. Special surface gauge
4. Tool-post wrench
5. 18″ flat-bastard file
6. Oil can
7. Spud bar
8. Lifting pads
9. 6′ folding rule
10. $1\frac{3}{4}$-lb. ball-peen hammer

MATERIALS

Wiping rags

The work involved in the operation of a plate planer may be summarized as follows:

PROCEDURE

1. Identify the plate which is to be planed.
2. Place the plate on the planer table.
   Have the crane operator assist.
3. Align the edge of the plate with the table-side of the ways.
   a. Place the special gauge at one end of the plate on the table-side of the ways.
   b. Adjust the indicator to register in one of the center-punch marks.
   c. Slide the gauge to the opposite end of the plate and check the alignment of the center-punch marks.
   d. Make necessary adjustments with the aid of the tool carriage and the cross-feed.
   e. Re-check the plate alignment.
   f. Clamp the plate securely to the table.
4. Identify the correct shape, from the markings on the plate, to which the edge is to be planed.
5. Obtain the correct template for the cut from the layout man.
6. Select the cutting tool for the job.
7. Adjust the cutting tool in the tool holder.
8. Manipulate the controls and run the carriage to the end of the plate where the cut is to begin.
9. Adjust the cross feed to take the first cut.
   Do not take a heavy cut at first. Allow the carriage to traverse the plate edge lightly to get rid of high spots.
10. Take the first cut and remove the high spots.
    Return the carriage to the starting point.
11. Adjust the cross feed to take a 1/16″ cut.
12. Take the second cut.
    Return the carriage to the starting point.
13. Make any tool adjustments that are necessary and continue the planing of the plate edge until the correct amount of metal has been removed.
14. Check the cut frequently with the template.

QUESTIONS

1. Describe the equipment ordinarily used to handle plates in and out of plate planers.
2. State how the operator identifies the correct shape of the plate edge to be planed.
3. Why are plate edges square-planed?
4. Name the various types of beveled edges.
5. Name the various types of grooved edges.
6. When is the control button marked "start" used?
7. What is the purpose of the control button marked "cut"?
8. How much metal should be removed from a square-planed edge with one cut?
9. Explain the method of determining whether the cut on the plate edge is correct.
10. If a plate edge becomes rough and humpy while it is being planed what should be done to correct the cutting of the tool?
11. Whose responsibility is it to grind the cutting tools for planing plate edges?
12. How often should the machine be oiled?
13. Name the locations where oiling should be done.
14. Explain how a plate edge is planed straight when the plate is longer than the machine.

MACHINE OPERATION NO. 5
KEEL BENDER

General Information

It often becomes necessary in the course of fabricating jobs in the boiler shop to bend keel plates and other similar pieces of steel plate. The plate shown in Fig. 188

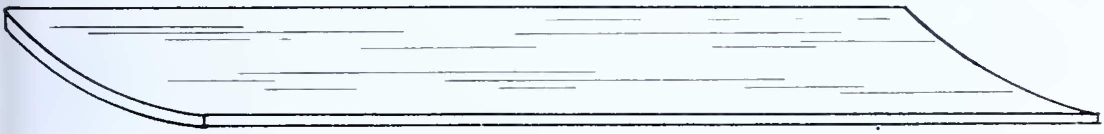


Fig. 188 — *Curved Plate*

has a slight curve the short way. Suitable upper and lower dies are bolted securely to the upper member (movable head) of the machine and to the lower part of the machine (the bed) and the work is placed between the upper and lower dies to be formed.

Interchangeable Dies

The keel bender shown in Fig. 189 is equipped to bend long plates (21′ limit) of any thickness up to about 2″. Interchangeable dies make it possible to do a wide

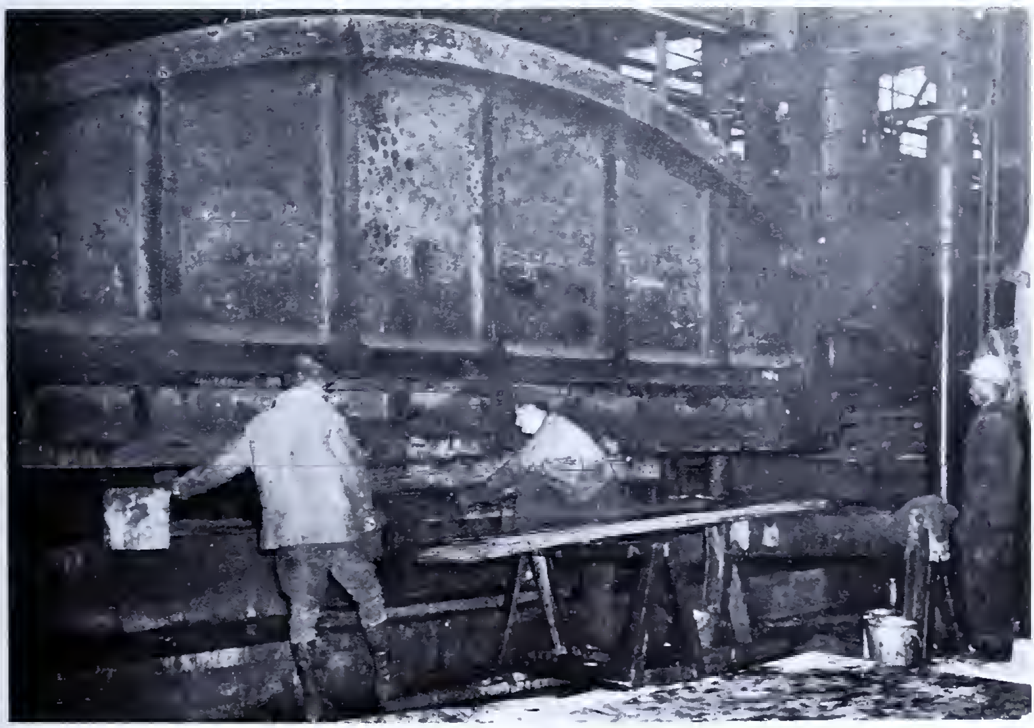


Fig. 189 — *Keel Bender*

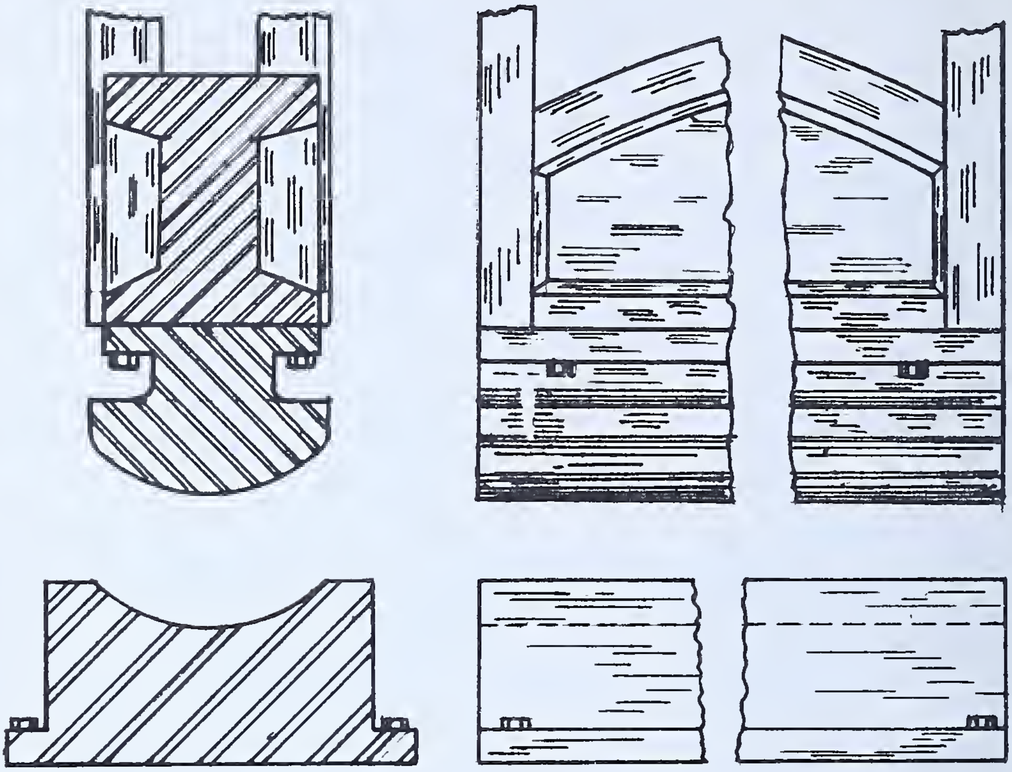


Fig. 190 — *Curved Dies Bolted in Place on Keel Bender*

range of work. The capacity of the machine is 750 tons. The illustration shows the operator and his helper placing a steel plate in the machine to be bent to an irregular shape.

Standard Die-Curve Range

There are several sets of different radii dies for this machine. These dies can be used to make almost any desired radius bend if shims are used in the lower die to stop the descent of the upper die at the correct height. Standard radii are shown in Fig. 191. The method of using shims to produce curves, other than standard, is shown in Fig. 192.

The operator must use good judgment in the use of shims for bending plates to the desired curve. It is well to make the bend a little less than the curve required and then to remove a shim before finally "setting" the curve. The shims must be of a width which will cover enough of the curve to prevent the formation of ridges or creases on the work.

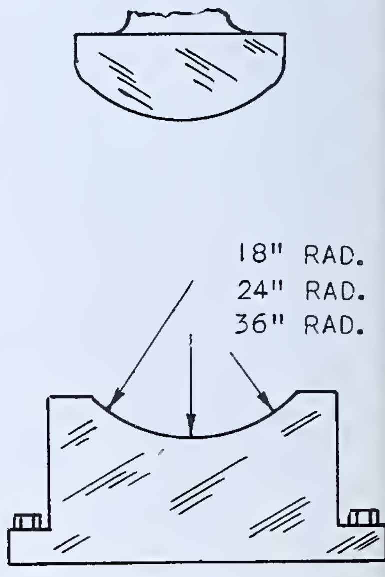


Fig. 191 — *Standard Radii*

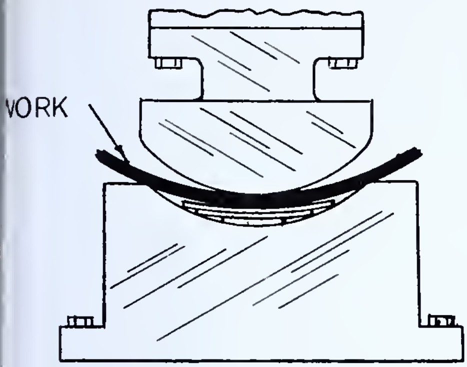


Fig. 192 — *Using Shims to Make a Special Bend*

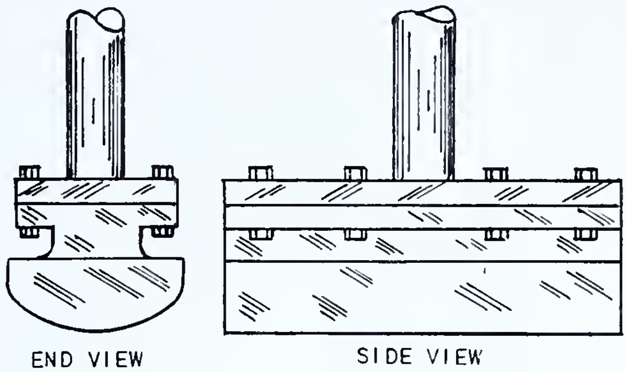


Fig. 193 — *Radius Dies for Flange Press*

Using Radius Dies on a Flange Press

Narrow and short plates can be bent on radius dies which are part of flange-press equipment. The upper die is shown in Fig. 193. Note the stem of the flatter plunger to which the upper die is bolted. The procedure for using these dies on a flange press is similar to their use on a keel bender. There are many jobs that can be done quickly and accurately in dies of this kind.

Forming a crown sheet for a boiler combustion chamber is a typical example of a job which is done in radius dies.

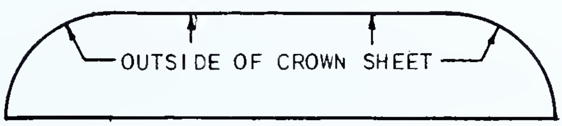


Fig. 194 — *Boiler Lower Wrapper and Crown Sheet*

Forming a Crown Sheet for a Boiler Combustion Chamber

Boiler combustion-chamber plates (called the lower wrapper and crown sheet) are partially shown in Fig. 195. These plates may be 6′ or more in length. The curved ends must be formed in the keel bender. Short plates up to 2′ or 3′ long are formed in the flange press.

If a die of the correct radius is available, it can be used without shims to produce the curve. Whether the job is done in the keel bender or in the flange press, the progressive steps are the same.

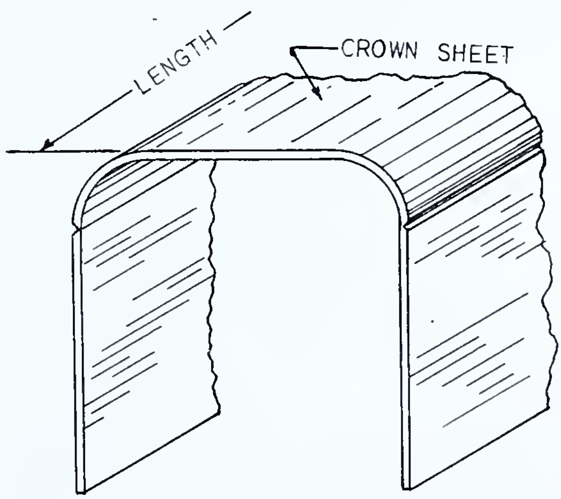


Fig. 195 — *Template Used to Check the Correct Curve and the Distance Between Ends*

The crown sheet is generally wide enough between curves that one end can be bent to the correct curve and after-

wards the sheet can be reversed and the opposite end bent to a curve without having the first bend interfere with any part of the machine. The outer end of the plate is supported with an automatic plate-lifting grab connected to the crane hook. The end of the plate can be raised to various heights afterwards and held in position while the bending is being done. The entire curve is not bent at one time because there

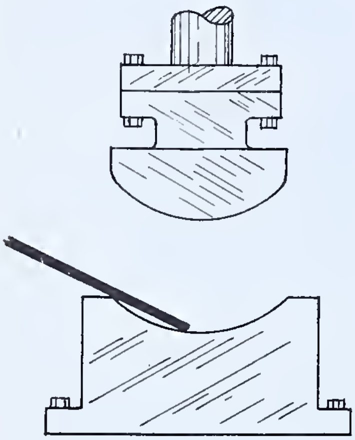


Fig. 196 — *First Position*

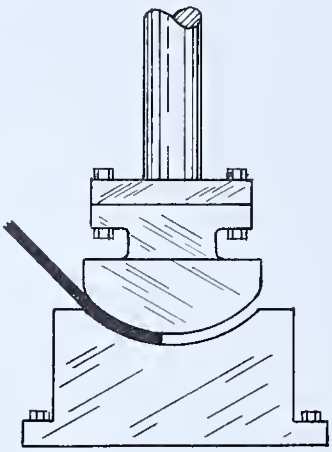


Fig. 197 — *Second Position*

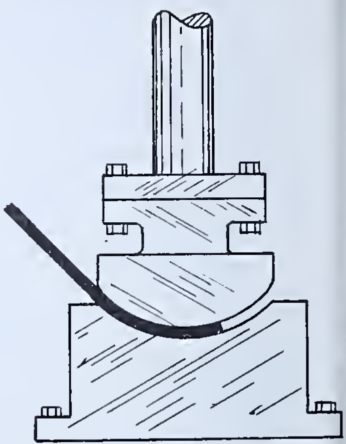


Fig. 198 — *Third Position*

would be too great a strain on the machine and the amount of curve could not be regulated so easily. Place one end of the plate in the dies as shown in Fig. 196, and make the first part of the bend. The plate is adjusted to project farther between the dies at each successive bending operation, and the bending is progressively continued (Figs. 197, 198) until the plate is formed as shown in Fig. 199. The operator must use good judgment in adjusting the plate in order to have the curve regular. If dies of the correct radii are not available, shims will have to be used, as shown in Fig. 192.

If the plate is longer than the length of the die, the first bend at Fig. 196 must be made all along the length by shifting the plate along until the entire length is bent. This shifting lengthwise is continued until the plate has been placed in the positions shown in Figs. 197, 198, and 199. When the curved ends have been fully bent, the plate can then be shifted lengthwise and a uniform bend can be worked from end to end.

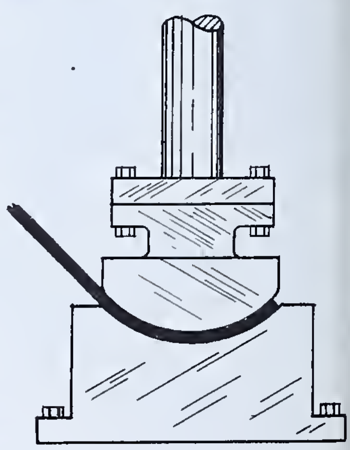


Fig. 199 — *Fourth Position*

Bending the Ends of Shorter Plates

Similar curved-end shapes on shorter plates can be made in the flange press. Ends of plates for cylinders of various diameters are curved on the radius dies previous to rolling them in the horizontal rolls. The amount of curve to bend in the ends of plates that are later to be rolled in the horizontal rolls is found by measuring

the center-to-center distance of the two bottom rolls in the machine in which the rolling is to be done.

The correct points from which this measurement should be taken are shown in Fig. 200.

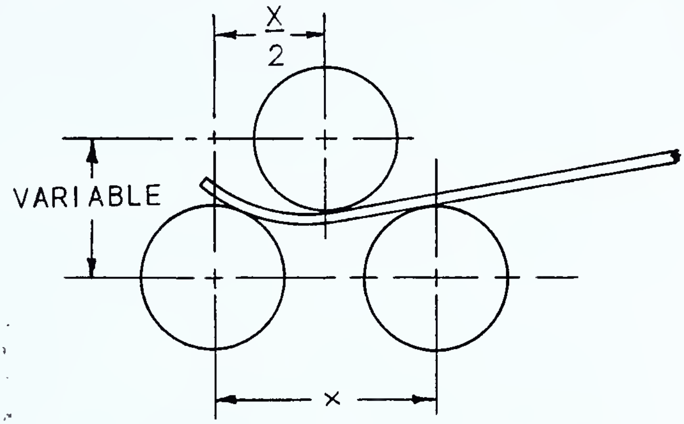


FIG. 200 — *Finding the Length of the Plate-End Bend*

KEEL-BENDER CONTROL

The operation of the keel-bending machine is controlled by four levers situated at the right on the front side of the machine. Safety throttles prevent the operation of more than two levers at one time. Two throttles are for the purpose of causing the upper die to descend. These throttles are always operating in pairs. The other two throttles are used to cause the pressure on the upper die to build up to 750 tons. The second throttles which build up this pressure are never used until the operator is sure first that the work is correctly placed in the machine and that the proper "sweep" of the bend has been checked.

The work involved in operating a keel bender for the purpose of straightening plates or for the purpose of forming the curved plates may be summarized as follows:

TOOLS AND EQUIPMENT

1. Template
2. Plate grabs
3. 12-lb. sledge
4. Plate spreaders
5. Chalk line
6. Straightedge

MATERIALS

Chalk

PROCEDURE

1. Obtain the correct dies and fasten them securely in their proper positions.

2. Obtain the plate or other piece of work which is to be formed.

   If shims are necessary for the job, have them ready to be used at the proper time.

3. Pick up the work and place it in position on the bottom die.

   The work may be picked up with the assistance of a helper if it is not too large. Where the work requires it, the crane and one or two helpers can be used. Use caution in hooking on to the plate with the crane. Make sure the fastenings are secure.

4. Manipulate the control valve to cause the upper die to descend.

   If the job consists of making successive passes, the procedure is the same as

when curving the end of a plate in the flange press. If the work consists of making a "dish" in a long plate and the die is not as long as the plate, several passes will be necessary, and the operator will need to use caution to prevent wrinkles and uneven places on the work. See Step 10 in the operation of a hydraulic, sectional flange press.

5. Manipulate the control valve and cause the upper die to return to its original position.

6. Continue to operate the keel bender as explained in the foregoing until the work is satisfactorily completed.

   Use the template or "sweep" frequently to make sure the bending is being done correctly. It is better to go over the plate several times to bring it to the proper curve rather than to bend it too much. Great difficulty is experienced in attempting to take the bend out when it has been bent too far.

7. Make a final check on the work to be sure it fits the template correctly.

QUESTIONS

1. What means are used to fasten dies in the keel-bending machine?

2. How are plate ends "set" to a 42″ radius when the die block is 24″ radius?

3. State how much sweep should be given the edge of a plate before attempting to roll it.

4. What markings are found on steel plates which determine the curve to which the plate should be rolled?

5. Explain why plates should be warmed during cold weather before attempting to bend or roll them.

6. Explain how plates are bent at a 90° angle.

7. Describe the dies which are used to make square bends.

8. Describe the number and type of dies which are used to bend a keel plate.

9. How are large jobs handled in the keel bender?

10. Compare the procedure followed in "setting" plates in a 750-ton keel bender and in "setting" plates in a 150-ton sectional flange press.

11. Who is responsible for the accuracy of the work done on the keel bender?

12. How many men are needed to operate a keel bender?

13. When should the hydraulic pressure be applied and when should it be released while the keel bender is in operation?

14. What would likely result if the operator neglected to close the valve which applies the hydraulic pressure when he leaves the machine?

15. What is likely to happen to the underside of a plate if the incorrect number and size of shims are used in the lower die?

16. Why are some plates heated before they are "set"?

MACHINE OPERATION NO. 6
VERTICAL BENDING ROLLS

General Information

Long, wide steel plates are more easily bent while they are standing on edge. The vertical rolls shown in Fig. 201 are mounted in the manner illustrated so that steel plates can be inserted and skidded along on the edge.

A steel plate with the ends "set" is shown in Fig. 202. Note the four skids which have been tack welded at *a* to the bottom edge of the plate. The skids allow the plate to slide along the steel-plate flooring with a minimum of friction.

The skids are made from 7/8″ round bar stock about 4″ long. They are welded to the finished edge of the plate as shown in Fig. 203.

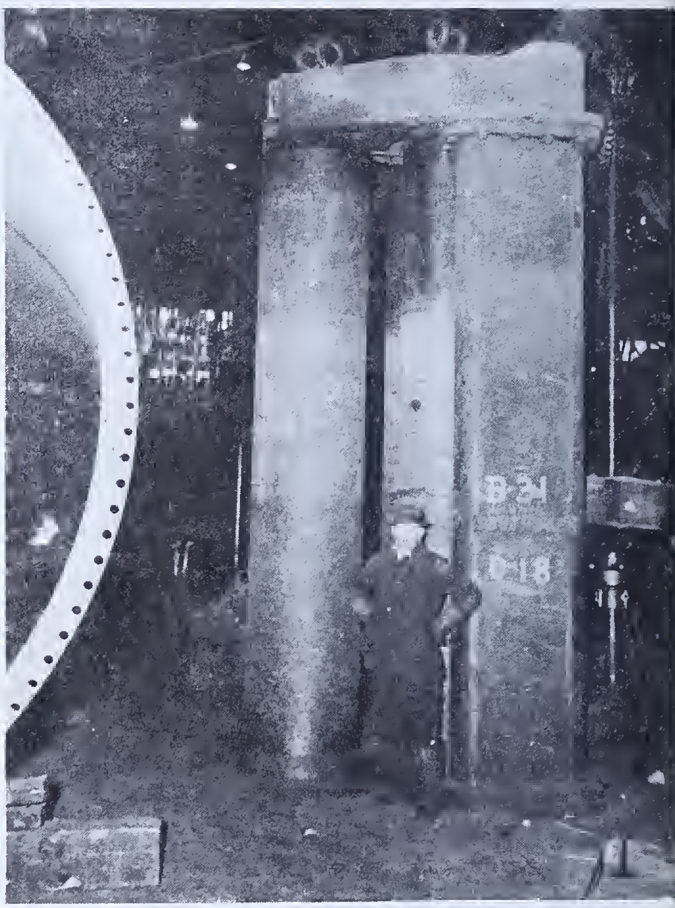


Fig. 201 — *Vertical Bending Rolls*

Roll-Operating Mechanism

The steel-plate flooring covers an area 50′ long and 20′ wide around the vertical rolls. The driving gears, motors, and other mechanisms are located in a covered pit under the steel floor. The only visible mechanism is that which operates the shaft which controls the movement of the in-and-out roll. The in-and-out roll is shown at *r* in Fig. 204. This roll must be adjusted in and out to regulate the amount of "set" as the plate is

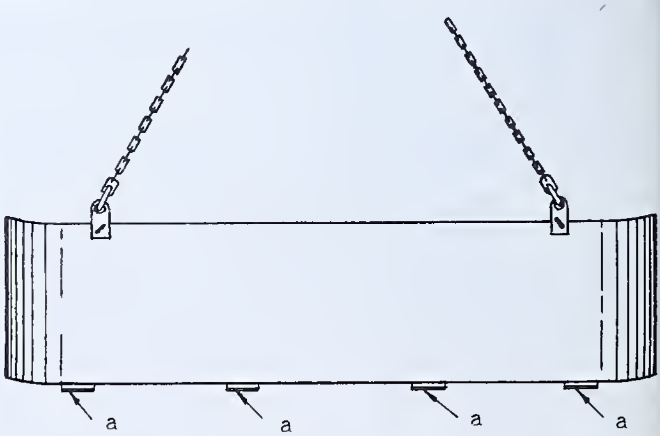


Fig. 202 — *A Steel Plate with Skids Attached*

passed back and forth between the three rolls as shown in Fig. 204.

Control Boxes

The control boxes are located so that the operator can see the plate as it passes through the rolls. There are two safety switches attached to the in-and-out roll which automatically control the feed-in screw. This safety device keeps the in-and-out roll feed screw from jamming in the nut and wrecking the mechanism.

If this safety device were not in operation the entire plate flooring might be ripped up and the operation of the machine could be delayed for days. The automatic switch should be set to allow the in-and-out roll only enough outward movement to function correctly. If the electric power is not shut off soon enough the automatic switch kicks out and cuts off the current.

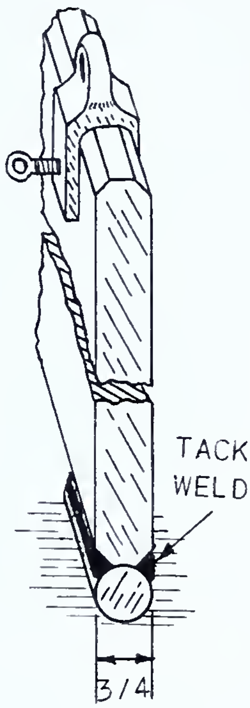


Fig. 203 —*Skid on Plate Edge*

Rolling a Plate

Plates may be rolled to form a part of a cylinder or to form a complete cylinder. If the plate is rolled to form a part of a cylinder the feed roll (in-and-out roll) is released by leaving the control lever in the "out" position until the rolls are far enough apart to allow the plate to be removed with the crane. Always make sure the lifting dogs are secured to the plate properly before attempting to remove it.

If the plate is rolled into a complete cylinder, the longitudinal seam is fitted and tack welded while it is still in the rolls. When it is removed from the roll it will be ready to weld.

Removing a Cylinder From the Rolls

To remove a cylinder from the rolls after it has been tack welded place the left control lever (Fig. 204) in the "out" position and adjust the feed roll (Fig. 204) until it is out far enough to allow the removal of the flush pin in the top feed screw.

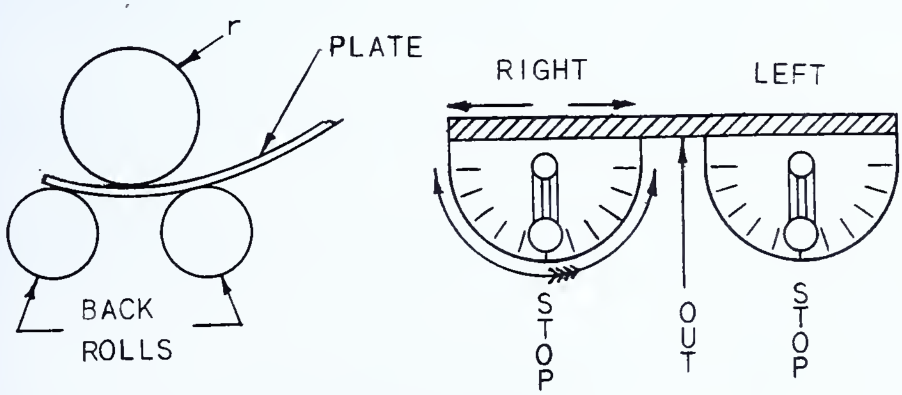


Fig. 204 — *In-And-Out Roll and Control Boxes*

After the pin is removed (Fig. 205) the crane is attached to two two-inch eye bolts in the top of the feed roll, and it is lifted until the lower end is clear of the lower housing. The feed roll is then swung away from the back rolls and it drags the cylinder clear and far enough away to allow it (the feed roll) to be set back in the housing. After the feed roll is set back in place, the flush pin is installed and the rolls are ready to roll another plate. The crane is then hooked onto the cylinder and it is removed.

Tools and Equipment

1. 2 Plate dogs
2. 1 1¼″ x 5′-0″ pinch bar
3. 1 Sweep — 5′-0″ long
4. 1 Welding machine
5. 12-lb. sledge
6. 1″ spud wrench
7. 2 Lap wedges

Materials

4 pcs. of ⅞″ x 4″ round-stock bar
4 angle clips
5 1″ x 4″ bolts and nuts
Welding rod
2¾″ x 4″ x 6″ plate straps

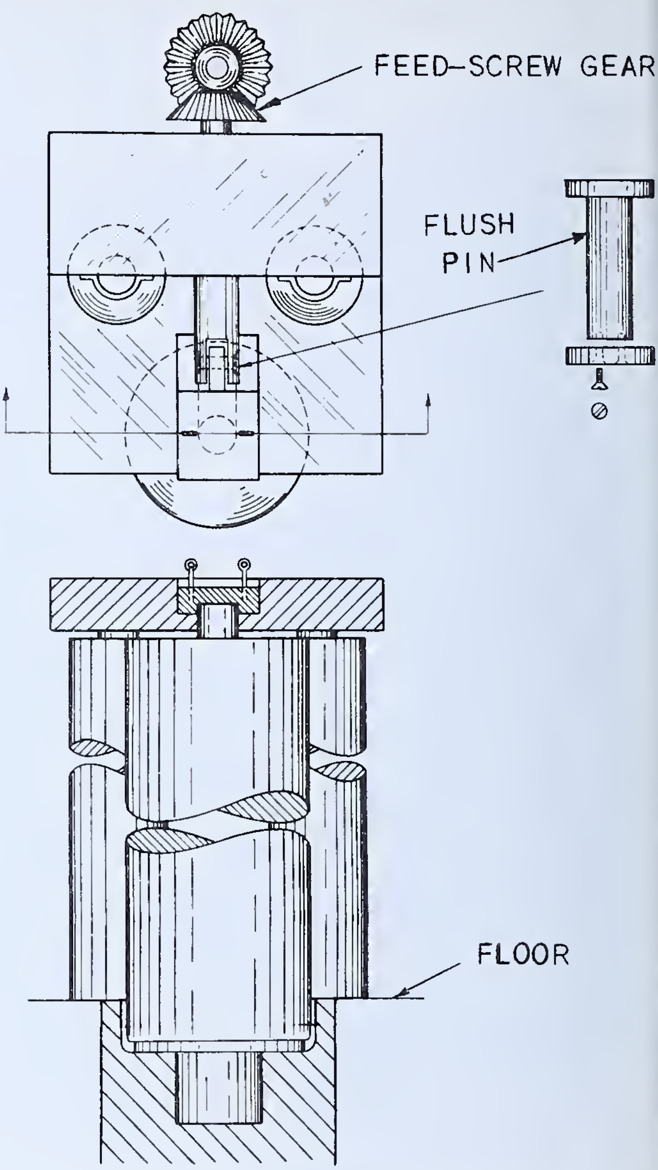


Fig. 205 — *Arrangement for Removing the Feed Roll*

The work involved in operating vertical bending rolls may be summarized as follows:

Procedure

1. Turn the left control handle to the "out" position and cause the feed roll to "open up" as shown in Fig. 206 at *B*.

2. Hook on to the plate with the crane.
   Make sure the lifting dogs are securely fastened to the plate.

3. Lift the plate to a vertical position for entering the rolls.

4. Slide the plate between the feed roll and the back rolls as shown at *C* in Fig. 206.

   The 7/8″ round bar tack welded to the finished edge of the plate will allow it to slide along easily.

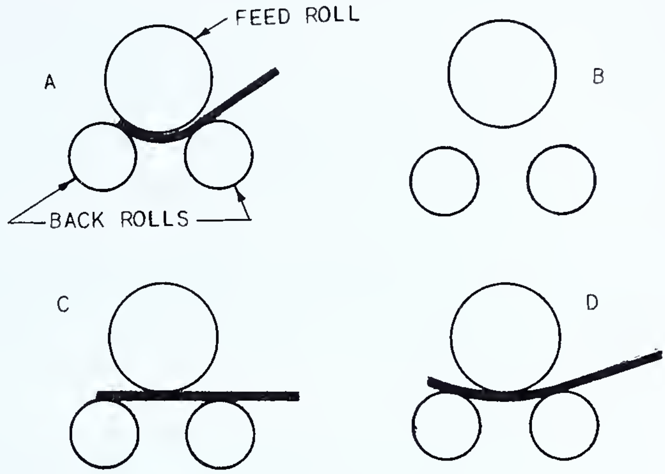


FIG. 206 — *Adjusting Rolls for Rolling*

5. Turn the left control handle to the "in" position and cause the feed roll to "close up" as shown in Fig. 206 at *D*, so that the plate is under pressure.

6. Turn the right control handle to the "back" position and cause the plate to pass between the rolls until the edge of the plate rides the back roll as at *A* in Fig. 204.

7. Turn the left control handle to the "in" position so that the feed roll will press a little harder on the plate.

8. Turn the right control handle to the "forward" position and cause the plate to pass between the rolls the required distance.

9. Continue the foregoing operations, Steps 5 to 8 inclusive, until the required radius or diameter is obtained.

QUESTIONS

1. Why are the vertical rolls used to roll long, wide plates?
2. What is the purpose of the skids which are welded to the finished edge of the plate that is being rolled?
3. Heavy plates require a greater number of passes back and forth through the rolls. State the reason for this.
4. How many control boxes are used to operate the vertical rolls?
5. Which control governs the feed roll?
6. What care should be exercised when using the feed roll control?
7. What happens if the plate is allowed to roll out, clear of the back rolls?
8. Why should the plate be held with pressure against both back rolls?
9. What happens if the edge of the plate should pass by one back roll?
10. Explain the purpose of the safety device which is attached to the feed-roll mechanism.
11. Explain the feeding operation which is performed on the seam before the cylinder is removed from the rolls.
12. Explain how the feed roll is removed and replaced after a cylinder has been rolled.
13. How many men are required to operate the vertical rolls?
14. Who is responsible for placing the work in the vertical roll?
15. What happens if the operator is careless and allows too much sweep to be formed in the plate?
16. Explain the purpose of a template in connection with the rolling operation.
17. State the number of different shapes that can be rolled on the vertical rolls.

MACHINE OPERATION NO. 7
RADIAL DRILL

General Information

A typical radial drill is illustrated in Fig. 207. A careful study of the illustration will show that the drill-spindle head can be moved close to or away from the column; the arm can be elevated or lowered on the column; the arm can be swung radially around the column; and the speed of the drill can be changed by shifting a lever. There are usually thirty to forty spindle speeds obtainable on an ordinary radial drill.

A piece of work is shown on the radial-drill table in Fig. 208. The capacity of the ordinary type of drill press is not great enough to allow a job of this kind to be handled speedily and with so great a degree of accuracy as can be accomplished by the use of a radial drill.

Instead of moving the work on a radial-drill table the work is clamped fast, the radial arm of the drill is swung about on the column, the head is moved in or out along

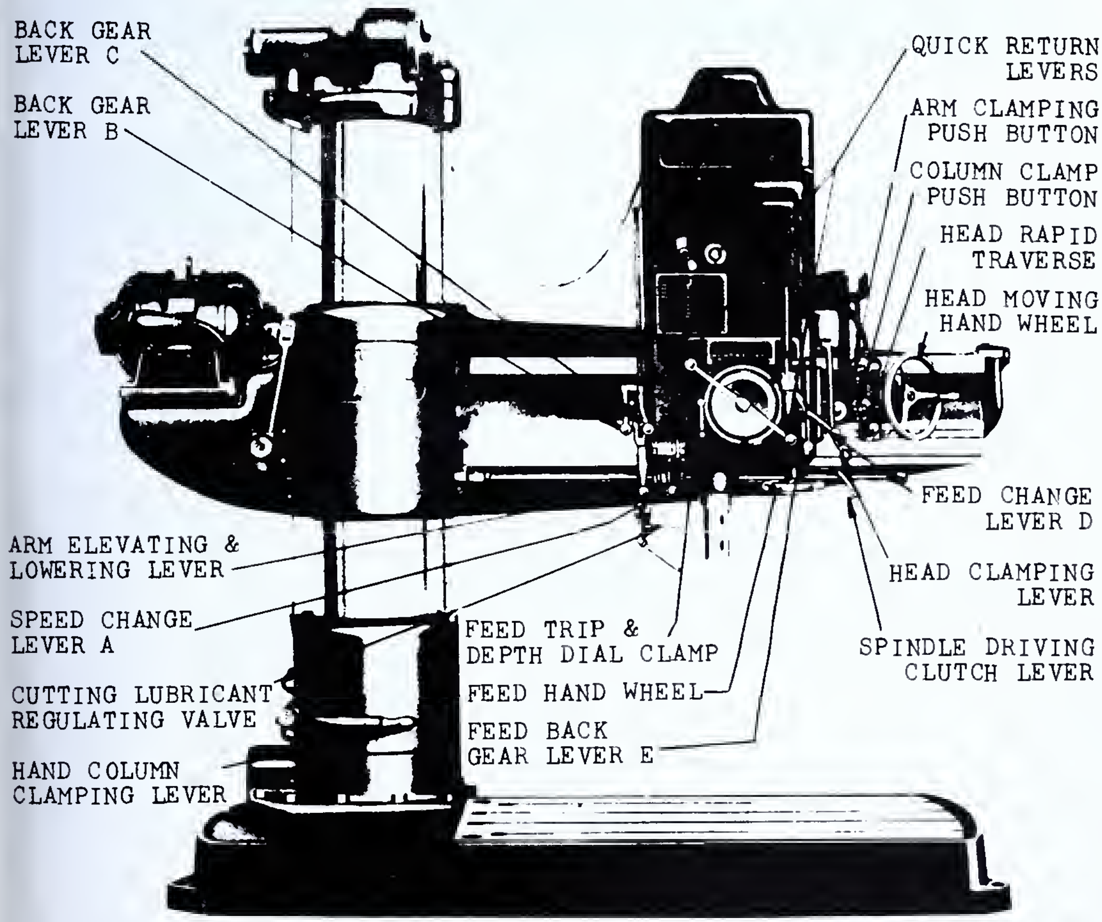


Fig. 207 — *Typical Radial Drill*

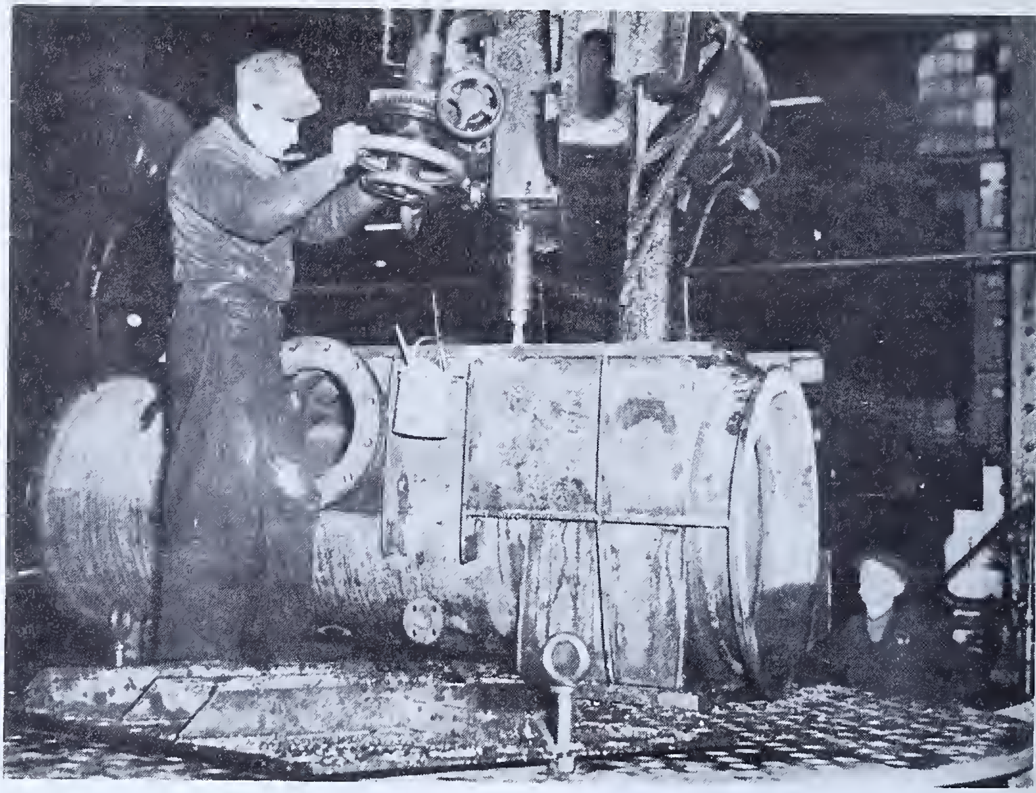


Fig. 208 — *A Radial Drill*

the arm, and the drill is centered directly over the center of the hole which is to be drilled. Correct manipulation of the control levers makes it possible to drill the series of holes shown in Fig. 209 without moving the work until all of the holes have been drilled.

Automatic Feed

After the drill has been centered over the center of the hole that is to be drilled, the arm can be locked on the column, the head can be locked on the arm, and the drill can be fed into the work automatically. The feed-change lever *D* is adjusted, the spindle-driving clutch lever is locked, and the drill feeds into the work until the operator releases the clutch lever.

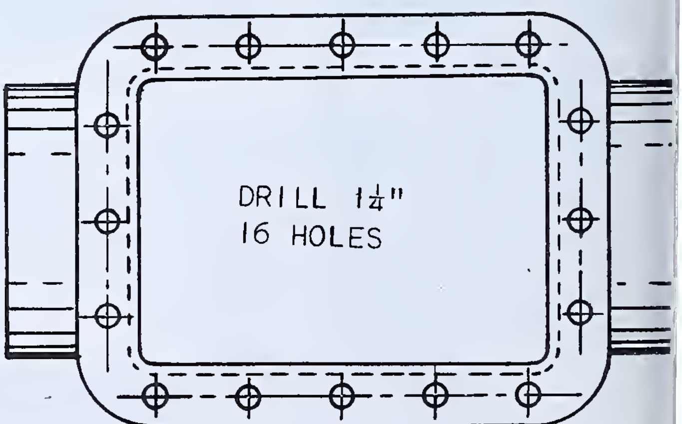


Fig. 209 — *Plan View of Work*

Lubrication

Note the can of lubricant hanging on the side of the job shown in Fig. 208. Follow the instructions of the foreman and apply lubricant only as directed. There are certain locations

bout the radial drill that must be kept lubricated with machine oil. Some of these ocations must be lubricated every day; other locations require lubrication once a veek. Too much lubrication is wasteful but it is better to use too much oil rather than o allow the running parts to become dry.

Operating the Radial Drill

Observe carefully the following rules when operating a radial drill:

1. Wear well fitting clothing. Loose sleeves, a flowing necktie, or ragged overalls are dangerous; they can catch on the revolving spindle and cause injuries.
2. Be sure of good footing. Standing on greasy or oily floors and plates can cause dangerous falls.
3. Make sure the drill, reamer, or boring tool is secure in the spindle. A loose tool in the spindle can cause bad scores, broken tools, or ruined work.
4. Watch the machining operation and be ready to act in an emergency.

The work of setting up and machining a piece of work in the radial drill may be summarized as follows:

Procedure

1. Study the blueprint of the job and identify the piece on which the work is to be done.
2. Obtain parallels and wedges and place them in readiness on the radial-drill table to level the work.
3. Have the work brought to the radial drill and place it on the table in the correct position for machining.

   The crane is used to lift heavy work to the tables.
4. Level the job on the table and in a position that will allow the head to reach the work at all necessary points.
5. Clamp the job securely to the table.
6. Obtain the correct drill, or boring tool, from the tool crib.
7. Place the tool in the spindle and make sure it is secure; avoid scoring the tool shank or the spindle.
8. Adjust the arm on the column to the correct height.

   The tool should clear the work enough to allow free movement of the arm when the tool is raised to the highest limit.
9. Determine the location to start drilling or boring the holes.
10. Swing the radial arm into the correct position for drilling or boring the first hole.
11. Adjust the head and arm to bring the tool over the center.

12. Lock the arm to the column and lock the head to the radial arm.

13. Manipulate the controls and lower the tool to the center to check for accuracy.

    If no adjustment is necessary, proceed.

14. Adjust the change-speed lever to the correct machining speed.

15. Adjust the feed lever to the correct feed.

16. Put the machine in motion, observe the speed of the tool, throw in the automatic feed and start to drill or bore the work.

17. Watch the tool and the work carefully to make sure the location of the tool is correct.

    If the machine appears to be "off center" stop the machine at once and adjust the tool. If no adjustment is necessary, proceed.

18. Release the feed and raise the tool when the machining in one location is completed.

19. Re-adjust the tool for the next location and proceed with the work as before.

20. Check the job carefully before releasing the clamps.

    Have the foreman check the job. If the work is approved, proceed to release the clamps.

21. Turn the job over to the next side to be machined.

22. Level the work on the new location and proceed as previously instructed.

23. Have the job taken away by the crane when it has been completed and checked.

    NOTE: Never release the clamps or move the work in any way until it is certain the job is correctly machined. It is difficult and sometimes impossible to re-set the work accurately after it has been moved.

QUESTIONS

1. State the location of the radial-drill table.
2. Where is the radial-drill column located?
3. On which part of the radial drill does the arm swing?
4. Where is the radial-drill head located?
5. On which one of the above four parts of the radial drill are all of the controls located?
6. Name some of the operations that can be done on a radial drill.
7. How should a 10′-0″ diameter plate be set up to drill several 2″ holes?
8. How should a 12″ diameter plate be set up to drill one 2″ hole?
9. Where, on a twist drill, is the size stamped?
10. At what speeds do various sized drills run?
11. Describe a pilot hole and its purpose.
12. Where, on a radial drill, is information regarding the speed of drills located?
13. What is meant by "spot-facing"?
14. State the size for a ¾″ standard tap drill.
15. What is the drill size for a 1″ standard tapped hole?
16. What materials require cutting lubricant?
17. State the drill size for a ⅜″ pipe tap.
18. What is the drill size for a ⅜″ standard tap?
19. When should a radial-drill operator wear gloves?
20. Name the small tools most commonly used by a radial-drill operator.

MACHINE OPERATION NO. 8
VERTICAL BORING MILL

General Information

The work which is done on a vertical boring mill is much like the work which is done in an engine lathe. The chief differences between a boring mill and an ordinary engine lathe are the position of the work, and the diameter-capacity of the face plate or work table. It is comparatively easy to place a large job on the vertical boring mill table and "true" it for turning or boring.

The vertical boring mill shown in Fig. 210 is a 14′-0″ machine and it has two heads. The heads can be adjusted in and out on the horizontal cross-head and they

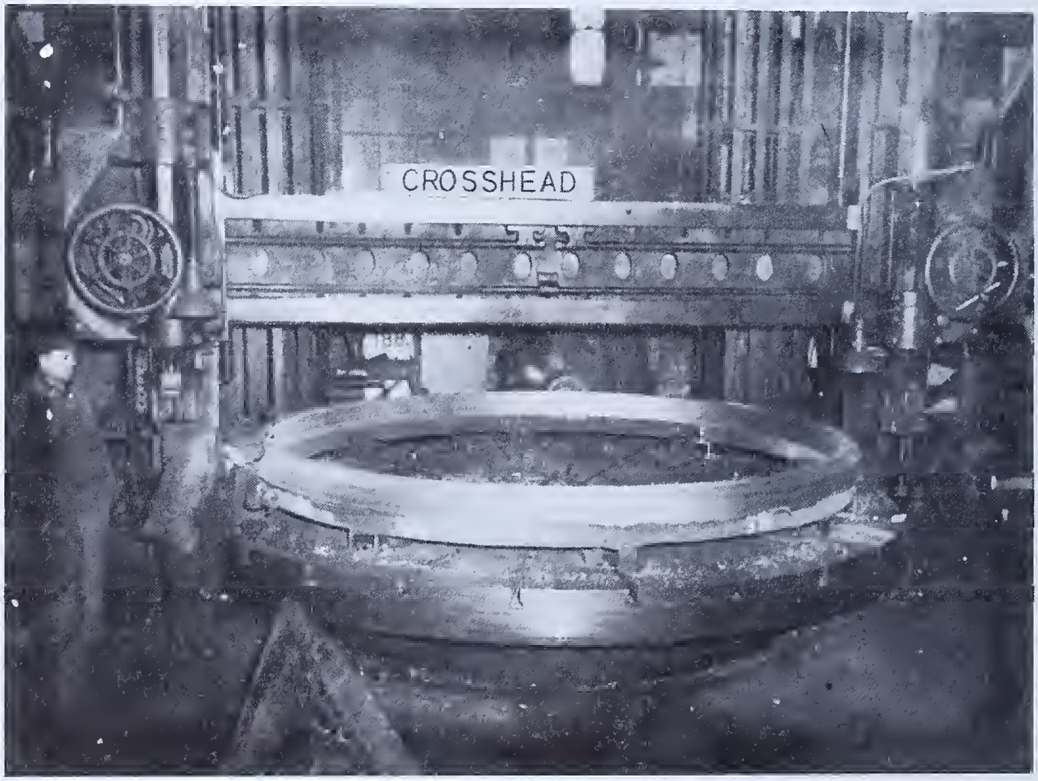


Fig. 210 — *Machining on the Vertical Boring Mill*

can be adjusted to cut simultaneously and at different diameters. Hand-adjusting wheels are shown in Fig. 210 at the right and left of the crosshead.

Clamping the Work to the Table

The work is laid on parallels and special clamps are forced against the inside or the outside of the job. Adjusting the clamps in or out provides a means to "true" the work so the cutting tool can take an even "cut" all around. The work must be clamped securely to the table before it is safe to take a cut.

A Typical Boring Mill Job

The ring flange shown on the table in Fig. 210 is one of the many jobs that can be turned or bored. The ring flange is machined to size and then it is welded to a cylindrical shell. An example of a ring flange which has been welded to a shell is shown in Fig. 211. Ring flanges are forged steel rings, made in halves which are welded together to form a continuous ring.

Annealing the Forgings

After the ring flanges have been forged and welded together they are taken to an annealing oven where they are annealed, thus relieving all stresses and softening hard

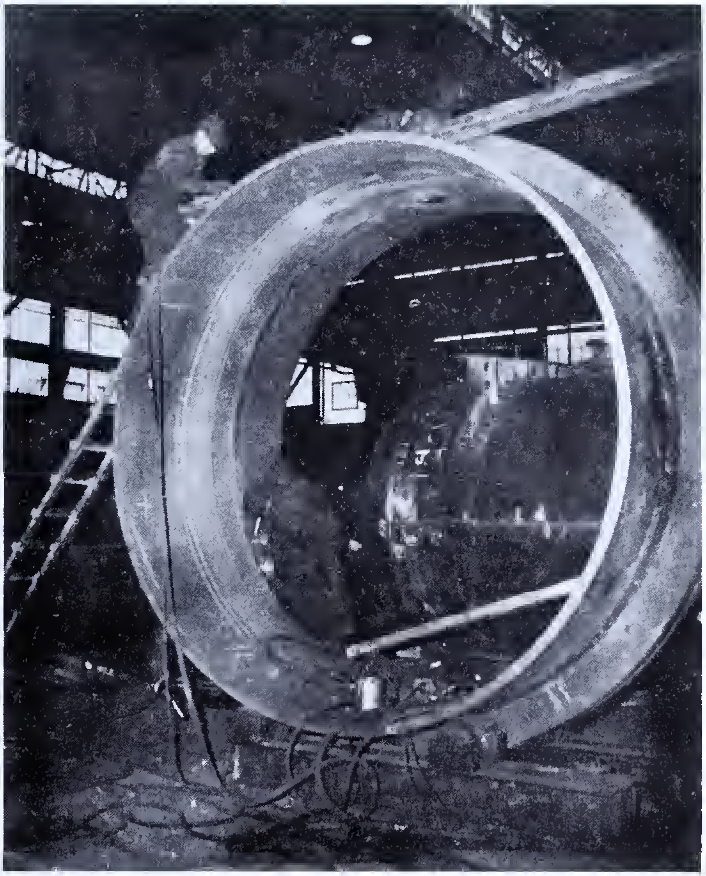


Fig. 211 — *Preparing Seams for X-Raying*

spots. A group of three ring flanges (Fig. 212) is shown on a car that has just been removed from the annealing oven. It will be noted that the bottom ring is lying on parallels. The other two rings are laid on top of the first ring. When the car is pushed into the oven the door is closed. The temperature in the oven is raised to 1600 degrees Fahrenheit. The heat is held at this temperature and the rings are left in the oven for a length of time which is equal to one hour for each inch of ring thickness. When the annealing is finished the weight of the rings has caused them to settle down to a uniform level as shown in Fig. 212. The car is pulled from the oven and the

rings are allowed to cool in still atmosphere They are then ready to be rough machined and finished.

FIG. 212 — *Preparing the Ring Flange for Stress Relieving*

MACHINING A DISHED HEAD

Another type of job which can be machined in a horizontal boring mill is shown in Fig. 213. The job is a dished head and the operator is machining the flange which fits the shell at this point.

Note the "posts"which hold the flange against the "spring" of the tool. Also the posts help support the head level on the machine table. Clamps are shown which hold the nozzle flange securely to the table.

A close-up of the tool post is shown in Fig. 214. Note the setting of the tool, the rake of the cutting edge, and the uniformity of the chip.

REQUIRED FOR MACHINING THE JOB SHOWN IN FIG. 210

TOOLS AND EQUIPMENT

1. 25-foot steel tape
2. Surface gauge
3. 1″ square-box wrench
4. 1¼″ open-end wrench
5. 10″ outside calipers
6. 18″ combination square
7. 12″ bevel protractor
8. 6″ steel scale
9. Bevel gauge
10. Round-nose roughing tool
11. Round-nose semi-finishing tool
12. Broad-nose square cutting tool

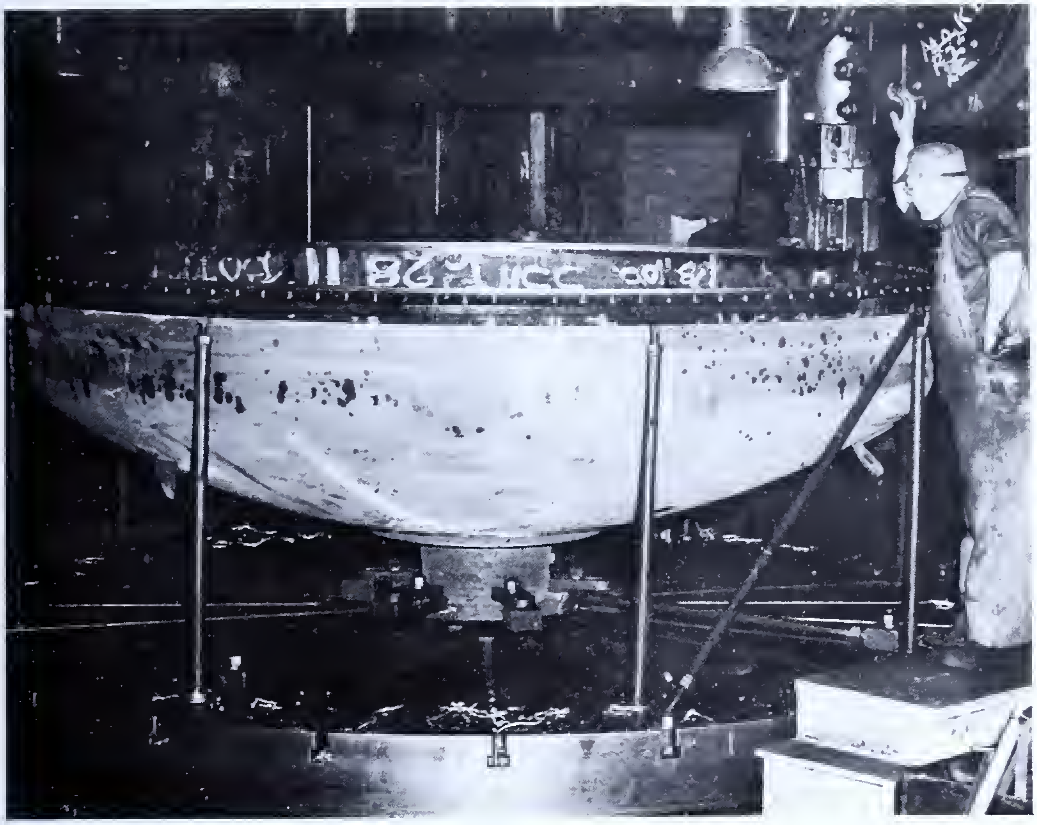


Fig. 213 — *Machining the Flange on a Dished Head*

13. Narrow square-nose tool
14. 60° wide beveling tool
15. ½″ round-nose tool
16. 6-foot folding rule
17. 1¾ lb. hand hammer
18. Center punch
19. Scriber
20. Set of steel stamps
21. Tool-post box wrench
22. Inside chuck jaws
23. Parallel blocks
24. Oil can
25. 1″ steel cable sling
26. Working platform
27. Broom and dust pan
28. Detail drawing

Required for Machining the Job Shown in Fig. 213

Tools and Equipment

1. Broad-nose tool
2. Narrow square-nose tool
3. ½″ round-nose tool
4. 60° bevel tool
5. 6″ scale
6. Depth gauge
7. 25-foot steel tape
8. Bevel gauge
9. Seven 1″ jack screws and pipe
10. Four 1″ jack screw struts
11. Can of cutting oil
12. Working platform
13. Detail drawing

MATERIALS

1¼″ x 7″ bolts and nuts
6 pieces 2½″ x 2½″ x 4″ (steel blocks)
6 pieces 1″ x 4″ x 6″ (steel straps)

MACHINING THE RING FLANGE

The ring-flange forging is placed on the boring-machine table in such a manner and in a certain sequence of steps that will permit the job to be machined accurately and with a minimum amount of re-setting.

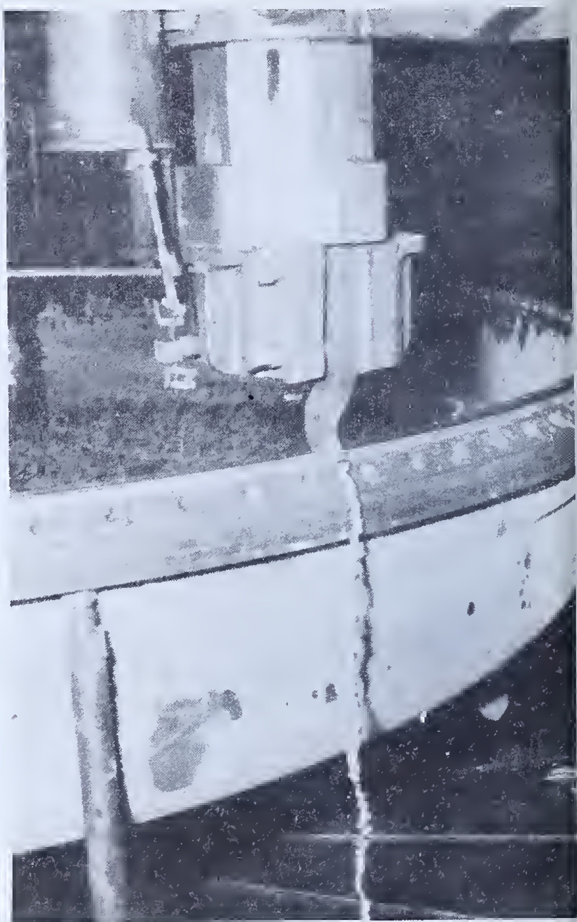


FIG. 214 — *Taking a Cut*

PROCEDURE

1. Have the craneman place the ring flange on the table as shown in Fig. 210, "true" the diameter, and clamp the job fast.

   Place the wide side down and on parallels as shown in Fig. 215.

2. Select a round-nose tool according to instructions from the foreman.

3. Set the tool and take a ⅛″ roughing cut across the work as shown at *a* in Fig. 215.

   If one cut does not clean the surface uniformly, set the tool deeper and take a second cut.

4. Release the clamps, have the craneman turn the job over, and place the ring with the rough-finished side down on the table as shown in Fig. 216. Use parallels as before.

   The dotted line in Fig. 216 indicates the metal that is to be removed at the next cut.

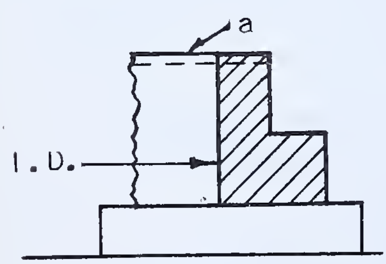


FIG. 215 — *Steps* 1 *and* 3

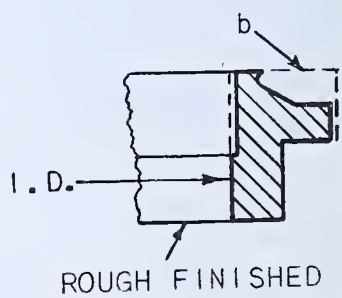


FIG. 216 — *Step* 4

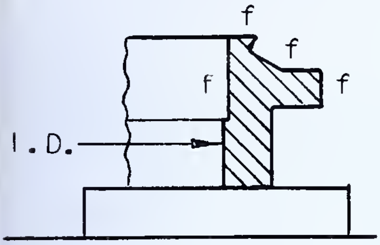


FIG. 217 — *Step* 9

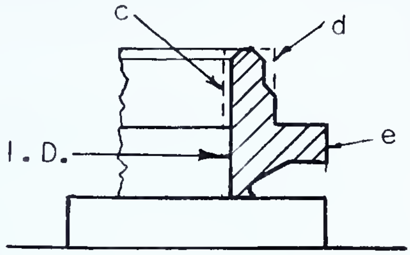


FIG. 218 — *Steps* 15 *and* 16

5. Clamp the job securely to the table after it has been "trued" to run concentrically.

   Test the concentricity of the work by using the point of the cutting tool as an indicator.

6. Select the correct cutting tool according to instructions from the foreman.
7. Set the tool to take a "clean-up" cut on the inside and outside diameters as shown by the dotted line in Fig. 216.
8. Select the correct cutting tool for "roughing out" the metal in the area indicated at *b* in Fig. 216.
9. Select the correct finishing tools according to instructions from the foreman and finish-machine the job to the dimensions given in the blueprint.

   The finished job should appear as shown in Fig. 217. The machined surfaces are marked *f*. Check with the foreman for his approval. When the work is approved, proceed.

10. Release the clamps, have the craneman turn the job over, and place the ring with the wide side down as shown in Fig. 218.
11. Attach an indicator to the tool post and true the ring flange with the finished surface that was previously machined.

    Check with the foreman for his approval. If correct, proceed.

12. Clamp the job securely to the table.
13. Indicate the finished surfaces again to make sure the job has not slipped during the clamping operation. If correct, proceed.
14. Select the correct tool according to instructions from the foreman.
15. Finish-bore the inside to meet the previously bored diameter as indicated at *c* in Fig. 218.
16. Finish-turn the outside as indicated at *d* in Fig. 218, according to the blueprint.
17. Check with the foreman for his approval. The job should appear as shown in Fig. 219.
18. If the foreman approves the job, have the craneman remove it from the boring-mill table and place it at the proper location on the shop floor.

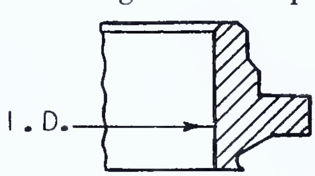


FIG. 219 — *Finished Ring*

QUESTIONS

1. How many men are needed to operate a vertical boring mill?
2. How are jobs set on the table so that they will be parallel with the crosshead and the tool post?
3. How many tool posts are used on a vertical boring mill?
4. Explain the methods used to secure the work to the vertical boring-mill table?
5. What is a chuck jaw?
6. Note the orderly and clean appearance of the floor in Fig. 210. When should the work be done of keeping this location clean and orderly? Who should do this work?
7. What is understood by the term "rough finish"?
8. Why are flange forgings annealed?
9. For how long are flange forgings allowed to "soak" in a temperature of 1600° Fahrenheit?
10. What is the reason for "blocking" (parallels) under flange forgings?
11. Whose responsibility is it to attend properly to such blocking?

PART V

GEOMETRY AND MENSURATION FOR BOILERMAKERS

INFORMATION SHEET NO. 5
LINES AND SHAPES

General Information

Boilermaking layout work consists of first determining from blueprints the true size and shape of the plates, bars, etc., from which the job is to be constructed and then marking according to the blueprint the lines to which the steel plate or bars are to be cut and shaped.

The Layout Man

The mechanic who performs the layout operations is called a layout man. The layout man must be able to use mathematics in making calculations. He must be able to read a blueprint; he must have a knowledge of descriptive geometry, which deals with the development of the surfaces of solids of all kinds; and he must have a thorough knowledge of the behavior of the construction material which he punches, rolls, and flanges.

Making Lines

The lines are made with a chalk line or a soapstone pencil.

Fig. 220 — *Chalk line*

Long, straight lines are made with a chalk line; short, straight lines are made by marking along the edge of a steel straightedge.

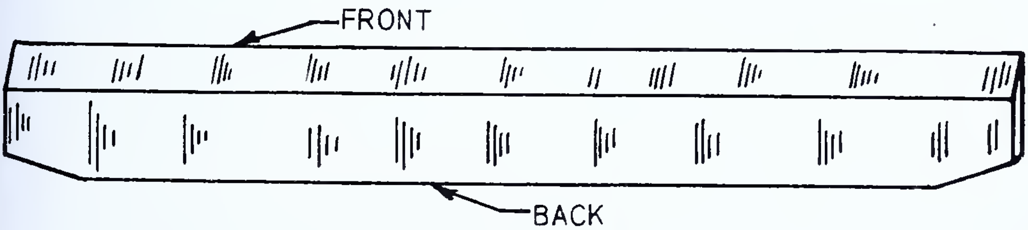


Fig. 221 — *Steel Straightedge*

Large circles are made with trammels; small circles are made with dividers.

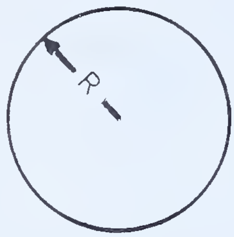
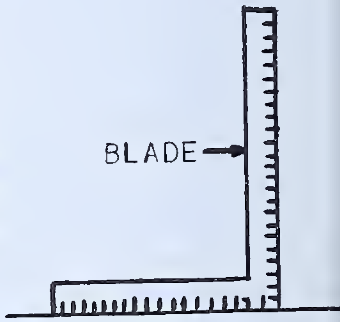


Fig. 222 — *Use Dividers*

Fig. 223 — *Strike Large Circles with Trammels*

Right-Angle Lines

Lines are made at right angles to each other, or are "squared up", by means of a steel square. The steel square is used to "square" one line with another only when the length of the line does not exceed the length of the steel square. Where a long line has to be squared with another long line, the trammels are usually employed. This method will be explained in Part VI, "To Lay Out a Flat Plate".



Measuring Lengths

Measurements along straight lines are made with an ordinary 2-foot rule, a 6-foot rule (Fig. 7), or a steel tape (Fig. 13). Measurements along curved lines may be made with the steel tape. The tape is held to the curve at short intervals, and the operation is repeated until the measuring is completed. A better method of measuring along curved lines is to use a measuring wheel (Fig. 18, Part II).

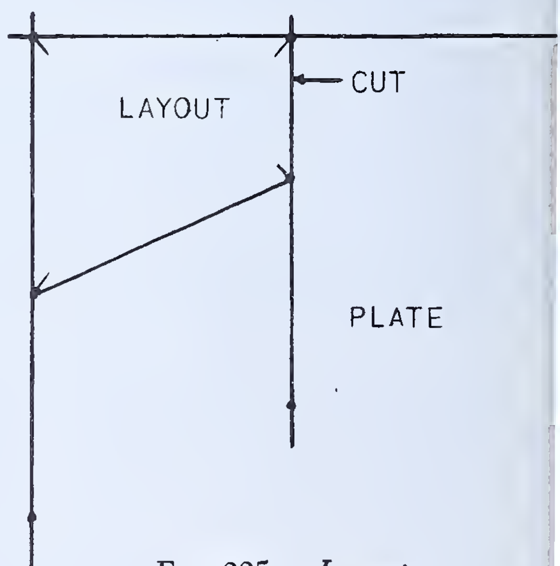


Fig. 225 — *Layout*

Making the "Layout"

Any group of lines that is marked on a surface to show where the material is to be cut is called a layout. Before any job can be fabricated (built up from one or more pieces), it must be laid out. A simple layout is shown in Fig. 225. A base line from which to measure is always established first. This may be a center line, or it may be a line which is mad[e] parallel with the edge of the plate, or it may be the edge of the plate.

Certain allowances are made for change in material structure when materials are bent, flanged, or rolled. These structural changes and rules for making allowances will be given in following instruction sheets at the time the rules are to be used.

Kinds of Surfaces

Generally speaking there are four kinds of surfaces which the mechanic considers when he does layout work. They are:

(a) Plane surface—

Fig. 226—*Plane Surface*

(b) Cylindrical surface—

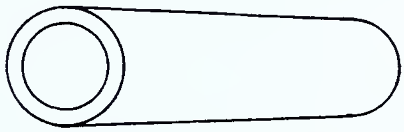


Fig. 227—*A Cylinder*

(c) Conical surface—

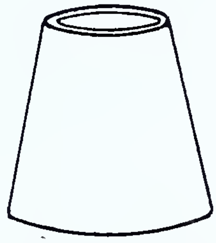


Fig. 228—*A Frustum of a Cone*

(d) Irregular curved surface—

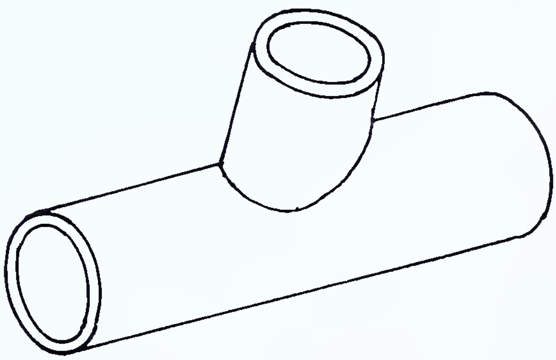


Fig. 229—*Irregular*

Developing Surfaces

The blueprint gives the dimensions of the work and shows the plane, cylindrical, conical, and irregular curved surfaces; but the blueprint does not show how to lay out the correct shape on flat material so that when the flat plate is cut out to the lines and shaped to a curve or formed at an angle, the finished job will be like the blueprint.

The layout man must know how to accomplish his objective by measuring correctly and using the rules to find circumferences, angles, curves, and irregular outlines; he must also know how to find the allowances necessary when he bends and forms materials.

The preliminary layout work is called "developing surfaces"; when the surfaces are developed correctly, the finished job will be like the blueprint. The instruction sheets which follow will show how to apply the fundamental principles and what tools to use for making layouts.

QUESTIONS

1. Describe briefly the work which a layout man is expected to do.

2. For what purpose is a set of trammels used?

3. What tool should be used to make a 6″ circle?

4. Name four kinds of surfaces on which the mechanic must make a layout.

5. What information is usually given on a blueprint?

6. What information is not found on blueprints?

7. Explain why a straight line on a formed piece of steel sometimes must be a curved line on a layout.

8. What is understood by the term "base line"?

9. Why is it necessary to make a layout?

10. Explain the meaning of the term "fabricate".

INFORMATION SHEET NO. 6
MENSURATION

General Information

The boilershop layout man deals with angles, diameters, circumferences, and sometimes areas. In that the final shape or form of material depends on the layout lines, a great amount of care is necessary in measuring and laying out the work. In some cases a curved line on the material becomes a straight line after the job is formed. For example: The base of a cone is curved on the layout, but when the cone is formed it is a straight line.

Mensuration Defined

Webster calls mensuration "The branch of applied geometry concerned with finding the lengths, areas, and volumes, from certain simple data of lines and angles." From the information given on the blueprint and a knowledge of simple arithmetic and the use of formulas, it is possible for the layout man to lay out the lines on either flat or curved surfaces accurately and obtain the required final shape by bending. The blueprint gives the simple data of lines and angles, and the layout man applies the formulas to arrive at the correct position for the lines when he makes the layout.

Geometry Defined

Webster defines geometry as "That branch of mathematics which investigates the relations, properties, and measurement of solids, surfaces, lines, and angles." From this definition we learn that lines are related to other lines. This relationship is called "ratio". For example: The circumference of a circle is always 3.1416 times the diameter. Therefore the ratio of the diameter to the circumference is always 1 : 3.1416. This ratio is termed Pi. A circle which is 1 inch in diameter measures 3.1416 inches around the circumference. Other relationships (or ratios) which apply to solids, surfaces, and angles can be found, by the use of formulas, in much the same way as the ratio of diameter to circumference.

The terms used will first be listed and explained.

Terms used in Mensuration and Geometry

Angle — Fig. 230. The figure formed by the coming together in a point of two straight lines, or the space bounded on two sides by such lines.

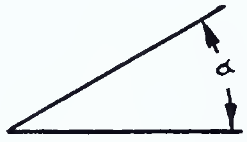


Fig. 230 — *Angle*

ARC — Fig. 231. A portion of a circumference.

FIG. 231 — *An Arc*

AREA — Fig. 232. The surface space of any figure enclosed by boundary lines.

FIG. 232 — *Area*

BASE — Fig. 233. The line or surface of a figure on which it is supposed to stand.

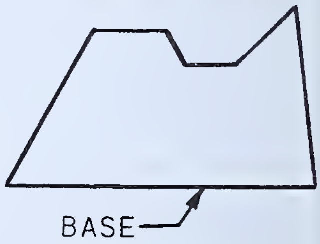


FIG. 233 — *Base*

L = Length of arc

CHORD — Fig. 234. A straight distance from tip to tip of an arc.

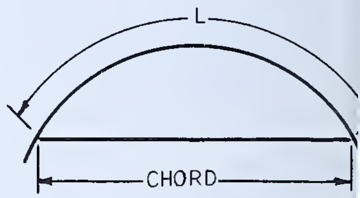


FIG. 234 — *Length of Chord and Arc*

CIRCULAR SECTOR — Fig. 235. The area enclosed between two radii forming an angle of less than 180° and the circumference of a circle.

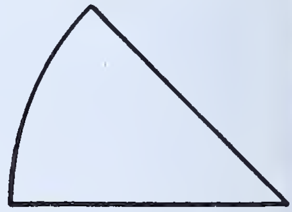


FIG. 235 — *Circular Secto*

CIRCULAR SEGMENT — Fig. 236. The area enclosed between an arc and the chord of the same arc.

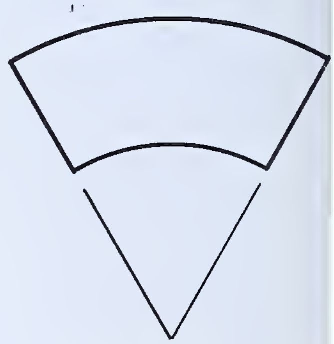


FIG. 236 — *Circular Segment*

CIRCUMFERENCE — Fig. 237. The distance measured from any point on a circle to the same point around the circle. There are 360° in any circumference.

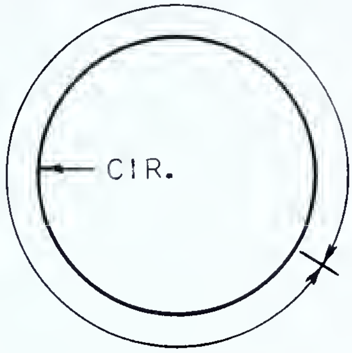


FIG. 237 — *Circumference*

CIRCULAR RING — Fig. 238. The space (area) enclosed between the circumferences of two concentric (having the same center) circles.

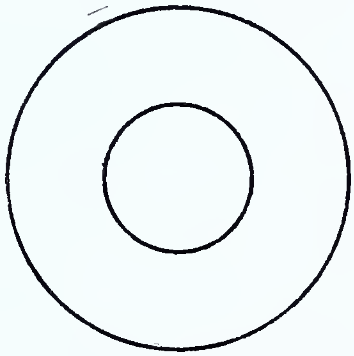


FIG. 238 — *Circular Ring*

CURVE — Fig. 239. The path of a moving point, not necessarily a circle.

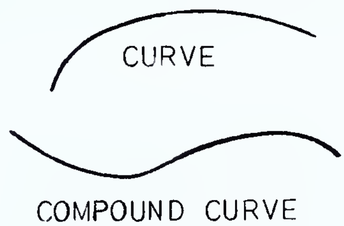


FIG. 239 — *Curves*

DIAGONAL — Fig. 240. The distance measured between opposite vertices of angles formed by the boundary lines of a rectilineal or polyhedral figure.

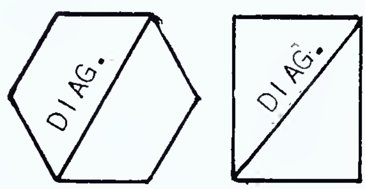


FIG. 240 — *Diagonals*

DIAMETER — Fig. 241. The distance measured from one side of a circle across the center to the opposite side.

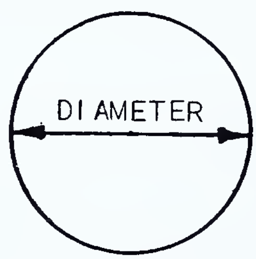


FIG. 241 — *Diameter*

Ellipse — A plane curve shaped somewhat like an egg except that both ends are curved the same and both sides are curved the same.

There are two methods employed to make an elliptical outline on a plane surface. One method produces a true ellipse. The other method produces an ellipse that is very nearly true.

To Make an Ellipse When the Diameters Are Given

The long diameter is called the major axis. The short diameter is called the minor axis. The major axis of the ellipse is to be 4′, and the minor axis is to be 2½′. Figure 242 shows how the ellipse is plotted. The heavy line is the ellipse; the light circles are the diameters of the major and minor axes; the dotted lines are radii; and the small triangles show the intersections of lines which are drawn parallel with the center lines of the circles through points which are found by spacing off equal distances on the circumferences of the circles.

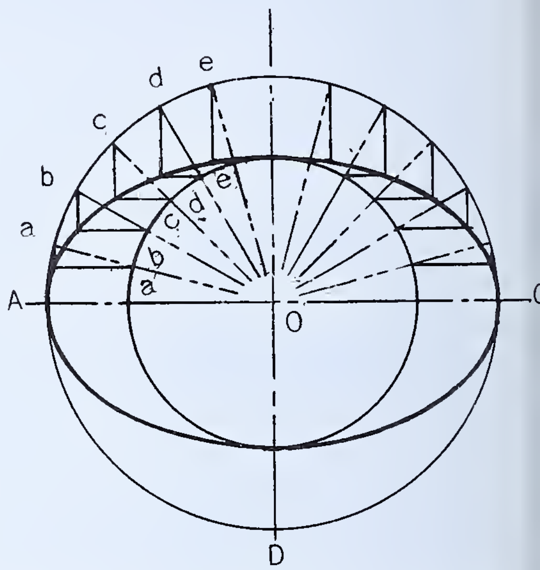


Fig. 242 — *Plotting a True Ellipse*

Procedure

1. With *O* as a center describe a circle 4″ diameter.
2. Scribe two center lines *AC* and *BD* through *O*.
3. With *O* as a center describe a circle 2½″ diameter.
4. Divide the circumference of the 4″ diameter circle into equal spaces; in this cas the number of equal spaces is twenty-four. (Larger circles are divided into mor equal spaces. The more divisions there are, the more accurate the ellipse will be.
5. Scribe radii through the points *a, b, c, d, e,* on the circumference, and cut the cir cumference at the 2½″ diameter circle at points *a, b, c, d, e.*
6. Through the intersections of these lines scribe the curve of the ellipse. Use a Frenc curve to scribe the ellipse. Make the curve of the ellipse as smooth as possible.

   Only one-quarter of the figure has been lettered. Proceed the same way with th other quarters of the circle.

To Make an Ellipse With the Aid of a Piece of String

Making an ellipse by this method requires close measuring and careful application The pins, around which the string passes, must be held perpendicular to the plane o which the ellipse is scribed; the scriber must be held perpendicular at all times; an the string must be kept tight during the scribing operation.

PROCEDURE

1. With *o* as a center describe a circle the diameter of the major axis.
2. Scribe two center lines *ac* and *bd* through *o*.
3. With *o* as a center describe a circle the diameter of the minor axis.
4. Set the trammels to the radius of the major axis.
5. With *b* and *d* as centers describe the short arcs on *ac* as shown at *x* and *y* in Fig. 243.

   The intersections *x*, *b*, and *y* are the points in which the pins are to be inserted. Each point is called a focus of the ellipse.

6. Place a piece of string over and around the pins at *x*, *b*, and *y*.

   The string is made endless by tying a knot at a point which will allow the inside of the loop to reach to *a* or *c* when it is drawn tight with the scriber.

7. Hold a scriber on the inside of the loop, and with the string drawn tightly scribe a line all the way around on the work.

   The figure thus formed will be the required ellipse.

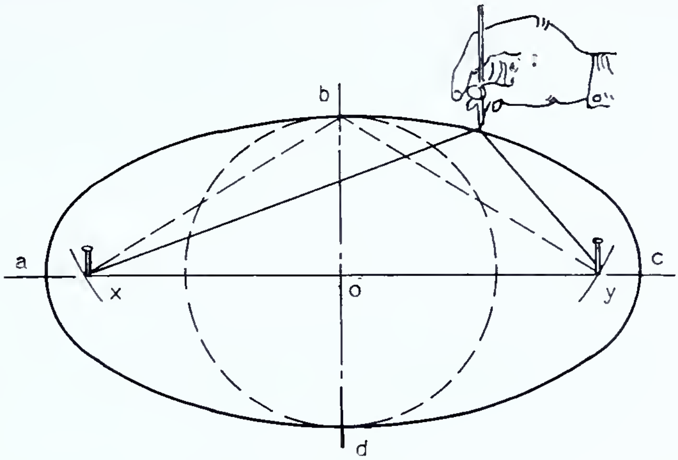


FIG. 243 — *Scribing an Ellipse with the Aid of a Piece of String*

FUNCTIONS OF A TRIANGLE — Fig. 244. The ratios or related values commonly considered when solving right-angled triangles. The "side opposite" is always opposite the angle under consideration.

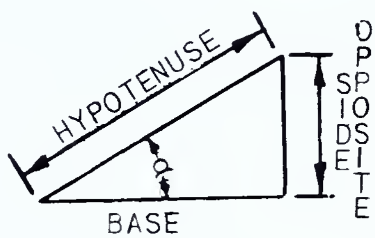


FIG. 244 — *Functions of a Triangle*

HYPOTENUSE — Fig. 245. The side of a right-angled triangle that is opposite the right angle.

NOTE: In blueprint reading the symbol ∟ means angle steel shape. α is often used in geometry to indicate "angle".

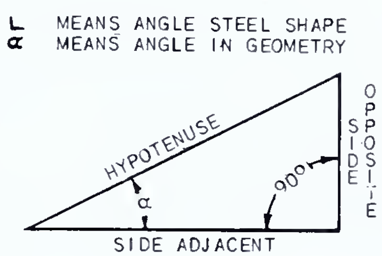


FIG. 245 — *Right Angle Side Names*

Parallel — Fig. 246. Lines are said to be parallel with each other or with an edge when they measure the same distance from each other or from that edge, for their entire length.

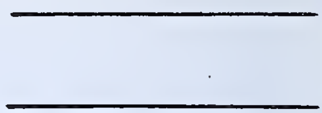


Fig. 246 — *Parallel Lines*

Perimeter — Fig. 247. The distance measured around the boundary line of any figure.

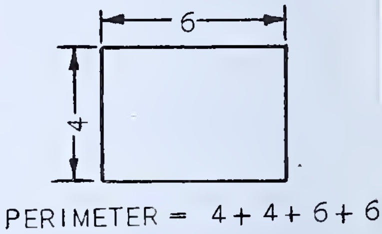


Fig. 247 — *Perimeter*

Radius — Fig. 248. The distance from the center of a circle to the circumference; one half of a diameter.

Fig. 248 — *Radius*

Rectangle — Fig. 249. A four-sided figure whose sides meet at right angles.

Fig. 249 — *A Rectangle*

Regular Hexagon — Fig. 250. A six-sided figure with equal sides and equal angles.

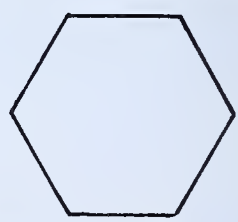


Fig. 250 — *Regular Hexagon*

Regular Octagon — Fig. 251. An eight-sided figure with equal sides and equal angles.

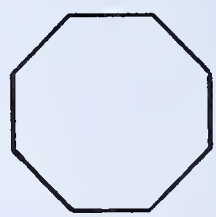


Fig. 251 — *Regular Octagon*

SQUARE — Fig. 252. A four-sided figure whose straight sides are all the same length; when one surface or line is at 90° with another surface or line, the first surface or line is said to be square with the second surface or line.

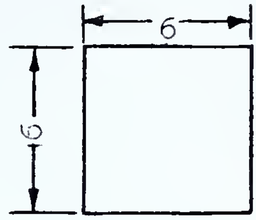


FIG. 252 — *Square*

TANGENT — Fig. 253. A line that touches a circumference at only one point and is perpendicular to the radius drawn to that point. The meeting place of two circumferences that just touch. The name given to one of the functions of a triangle.

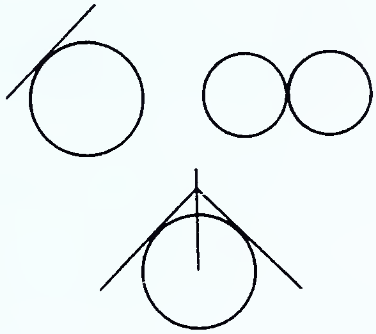


FIG. 253 — *Tangents*

TANGENT POINT

The meeting point of two straight lines which are tangent to the same circle.

TRIANGLE — Fig. 254. A figure having three straight sides and three angles.

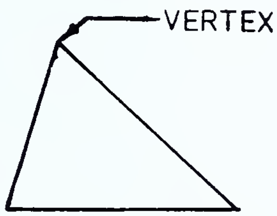


FIG. 254 — *Triangle*

TRIGONOMETRIC FUNCTIONS — Fig. 255. The ratios or related values involved in the mathematics of solving triangles.

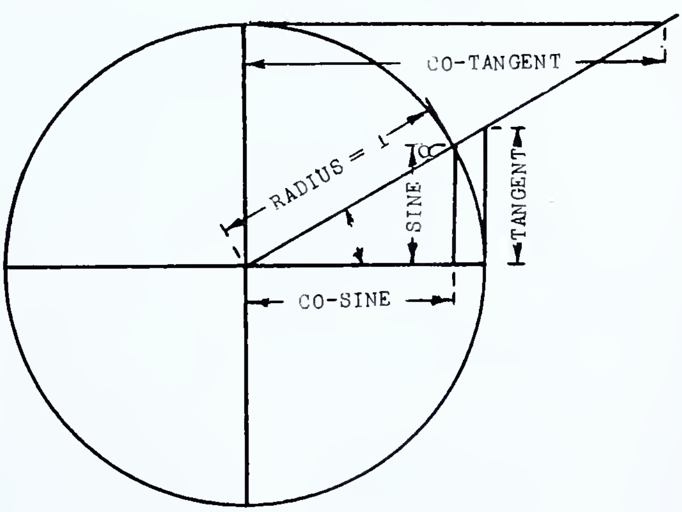


FIG. 255 — *Trigonometric Functions*

RIGHT-ANGLED TRIANGLE — Fig. 244. A triangle having one right angle.

VERTEX — Fig. 254. The point opposite and farthest from the base.

VOLUME — Fig. 256. The cubic contents of a container; the number of cubic inches contained in a mass. 3 x 3 x 3 = 27.

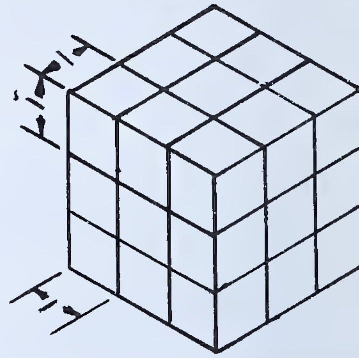


FIG. 256 — *Volume*

QUESTIONS

1. **What technical term is applied to the process of finding areas and volumes?**
2. **When the relationships of surfaces and angles are investigated what branch of mathematics is used?**
3. **What is understood by the term ratio?**
4. **State the ratio of the circumference of a circle to its diameter.**
5. **Name the ratio of a circumference to the diameter as it is usually spoken.**
6. **How many degrees are there in a circumference?**
7. **How is the area of a square found?**
8. **State the method for finding the area of a rectangle.**
9. **What is the difference between a square and a rectangle?**
10. **Where is the diagonal drawn on a regular hexagon?**
11. **What is the difference between a regular hexagon and an irregular hexagon?**
12. **State the radius of a 7½″ circle**
13. **When are two lines parallel?**
14. **Name the longest side of a right-angle triangle.**
15. **What is the sum, in degrees, of the angles in a triangle?**
16. **State the volume, in inches, of a 10″ cube.**

PART VI

BOILERMAKERS' LAYOUT PROCEDURE

JOB SHEET NO. 1
TO LAY OUT A FLAT PLATE

General Information

Steel plates come into the shop just as they are received from the mill. The edges are rough and wavy as shown in Fig. 257. The sides of the plate are not square with the ends. Before the plate can be worked into the desired shape for the job shown on the blueprint, it must be accurately laid out to the correct size.

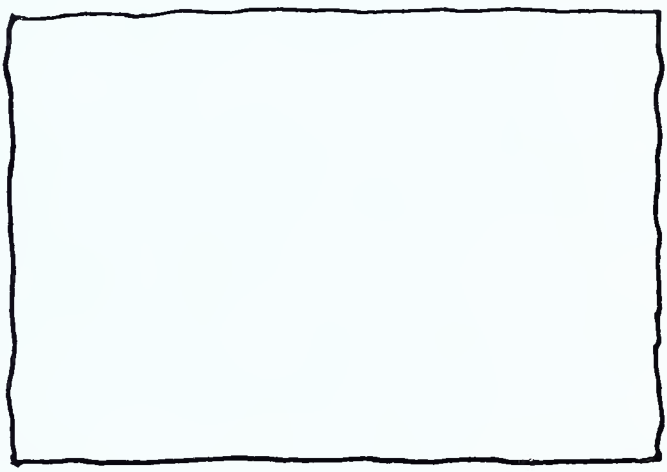


Fig. 257 — *A Rough Steel Plate*

Laying Out the Size

The lines on the plate are made with a chalk line. The dimensions are taken from the blueprint. As there is no straight edge on the plate from which to "square off" lines, a base line must first be established. A base line is so called because it is from this line that measurements are taken for the location of all other lines.

Tools and Equipment

1. Fifty-foot steel tape
2. Trammels
3. Hammer
4. Center punch
5. Chalk line
6. Blueprint

Materials

Chalk — Soapstone pencil

Procedure

1. Study the blueprint carefully to find the plate size and shape.

The information given on the blueprint is shown in Fig. 258. The ends of a

plate are always understood to be square with the sides when there is no ang dimension given. The rough plate is shown in Fig. 259. The letters in the figu are for reference only and are not found on shop blueprints. Follow the ste given in the procedure, and refer to the letters in the figure to understand t layout procedure clearly.

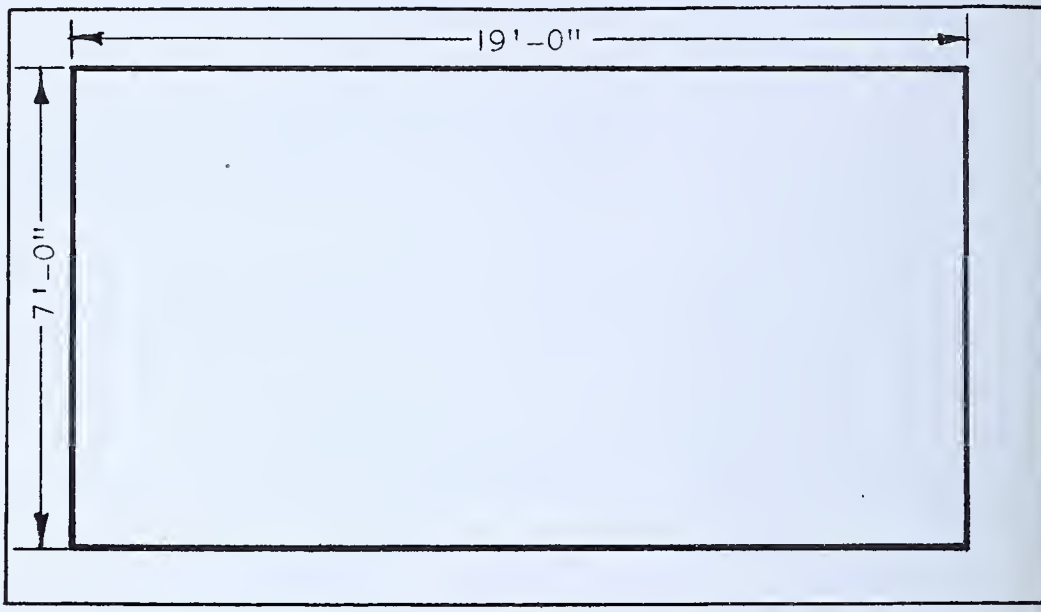


Fig. 258 — *Blueprint of Plate*

2. From the front edge of the plate, measure back ¼″ as shown in Fig. 259 at and *b*, and mark with soapstone.
3. With the chalk line held through these two marks and stretched taut, snap t line *a-b* as shown.

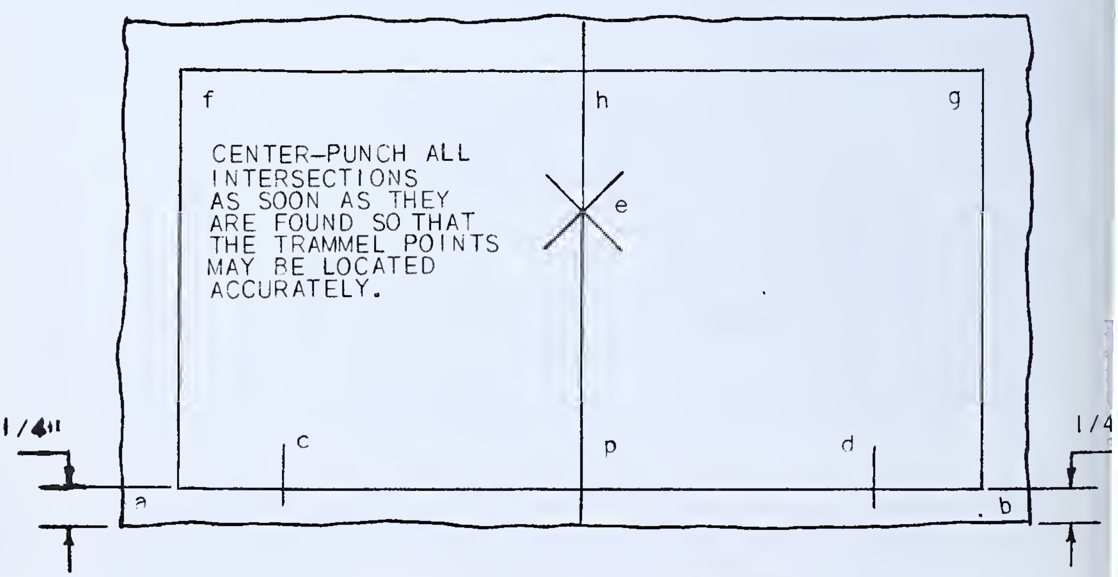


Fig. 259 — *Laying Out a Plate*

4. Measure from either end of the plate and find the center of the line *a-b*.
5. Mark the center *p* with soapstone.
6. Set the trammels to a distance *p-c* or *p-d* which is about three fourths of the distance *p-a* or *p-b*.
7. With *p* as a center strike two short arcs as at *c* and *d*.
8. Set the trammels to a distance that is about 6″ more than distance *p-c* or *p-d*.
9. With *d* as a center strike an arc as at *e*.
10. With *c* as a center strike an arc as at *e*.

    The two arcs should intersect like the letter *X*.
11. With the chalk line held through points *p* and the intersection of the arcs at *e*, stretch the line taut and snap the chalk line *p-h*.

    Line *p-h* is at right angles to, or "square" with, line *a-b*.
12. Set the trammels to 7′-0″ (use a long beam).
13. With one trammel point set on point *a*, strike an arc through point *f*.
14. With one trammel point set on point *b*, strike an arc through point *g*.
15. With the chalk line held through points *f-g*, stretch it taut and snap the line *f-g*.
16. Set the trammels to half the length of the plate given on the blueprint.
17. Set one point of the trammels on *p*, and strike an arc cutting line *a-b* at *b*.
18. Set one trammel point on *h*, and strike an arc cutting line *f-g* at *f* and line *f-g* at *g*.
19. With the chalk line held through points *a-f*, stretch it taut and snap the line *a-f*.
20. With the chalk line held through points *b-g*, stretch it taut and snap the line *b-g*.
21. With the center punch, mark the chalk lines at intervals of 6″. Begin at the intersection of the border lines. Also center-punch-mark the center line.

    The chalk lines are center-punch-marked 6″ apart (Fig. 261) if the plate is to be brought to size by burning with the acetylene torch.

    If the plate is to be planed to size, the corners are center-punch-marked three times each way. The punch marks (Fig. 260) are about 1″ apart.

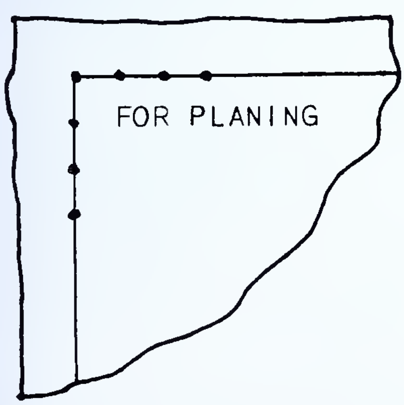


Fig. 260 — *Center-Punch Marks One Inch Apart*

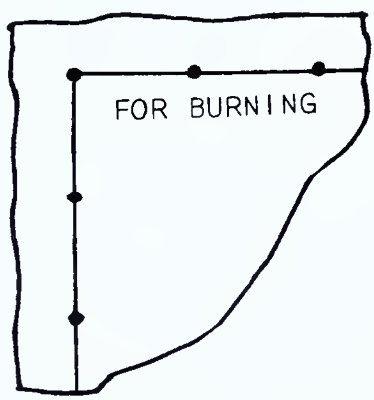


Fig. 261 — *Center-Punch Marks Six Inches Apart*

QUESTIONS

1. What is the usual amount to be allowed between the edge of a plate and the first working line?

2. How is the location for the center line *h-p* found on working line *a-b*, Fig. 259?

3. What distance apart should the trammel points be set to line *d* on line *a-b*, Fig. 259?

4. What two centers are used to erect the perpendicular line *h-p* with line *a-b*, Fig. 259?

5. Why are the trammel points set farther apart when stepping off distances *d-e* and *c-e* than when stepping off distances *p-e* and *p-d*, Fig. 259?

6. Explain how the width of the plate is laid out in Fig. 259.

7. How is the length of a plate given on the blueprint?

8. What part of the length of a blueprint dimension is used to obtain distance *h-g* or *h-f* in Fig. 259?

9. How much margin for machine planing should be allowed on all the edges of a laid-out plate?

10. What is understood by the term "burning line"?

11. How is a plate layout checked to find if it is square? See Fig. 265.

12. What center markings are placed on the plate to assist the planer operator to correctly set the plate on the planer table?

JOB SHEET NO. 2
TO LAY OUT A CYLINDER

General Information

The cylinder shown in Fig. 262 is to be welded along the seam. The bevel for the weld is planed on the edges of the plate before it is rolled into cylindrical form. The plate must be laid out with the correct allowance for upset and stretch in the metal if the cylinder is to be the right size when rolled.

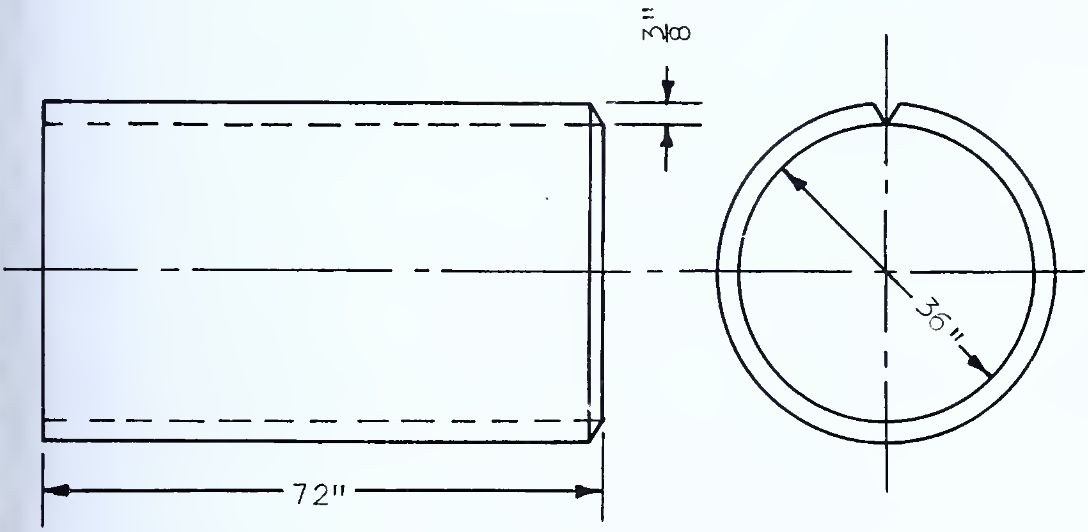


Fig. 262 — *A Rolled Cylinder*

Neutral Axis

The edge of a flat 3/8″ plate is shown in Fig. 263. The next figure, 264, shows the same plate bent in a curve.

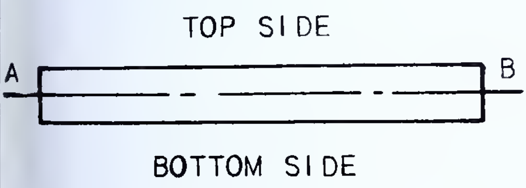


Fig. 263 — *Edge of a Flat 3/8″ Plate*

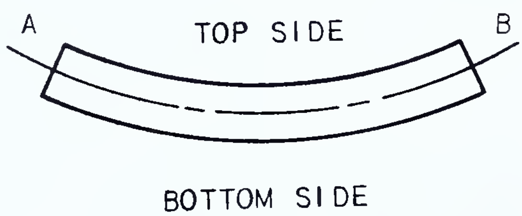


Fig. 264 — *Edge of the Plate Bent in a Curve*

The length of a 3/8″ plate which will form a cylinder 36″ inside diameter when rolled is 114.27″ or 114.25″ or 9′ 6¼ inches. The method of calculating this length is outlined on Pages 144, 145, and 146.

Make the Layout on the Correct Side of the Plate

The layout should be made on the plate surface on which the heat numbers are stamped. After the cylinder is rolled, the inspector must see and make a record of all mill marks. The layout surface of the plate is kept to the outside when it is passed through the rolls.

Making the Layout

As soon as the correct length of the plate is found, make the layout as in Job Sheet No. 1, Fig. 259 — "*Laying Out a Plate*".

Tools and Equipment

1. Folding rule
2. 50′ conversion tape
3. Trammels
4. Ball-peen hammer
5. Center punch

Materials

Paint
Marking brush

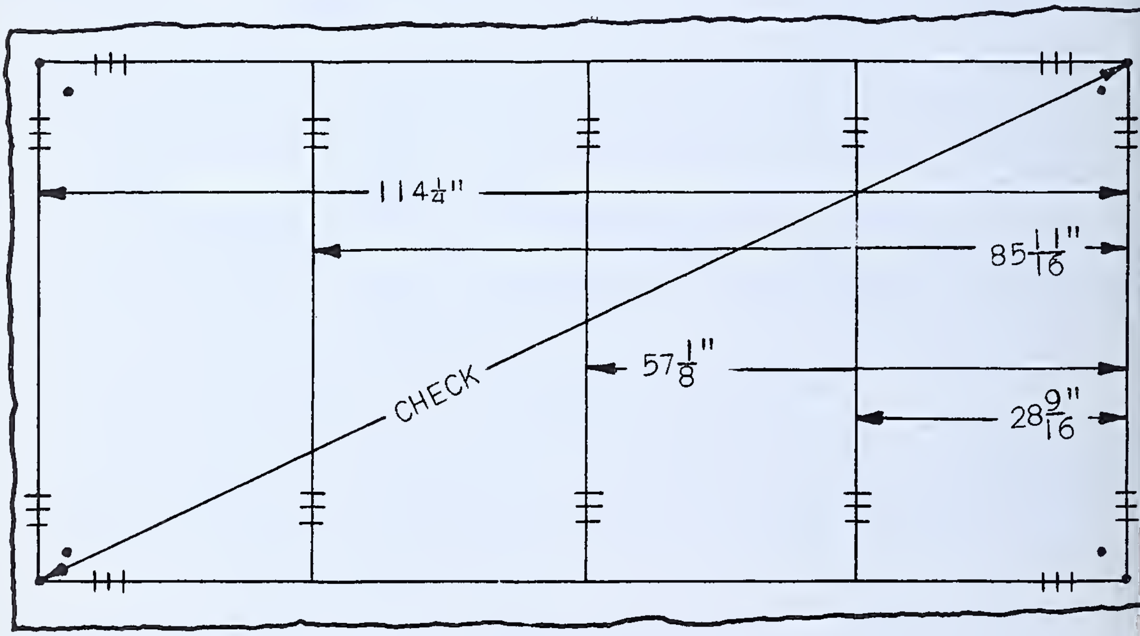


Fig. 265 — *Plate Layout for Cylinder*

The top and bottom sides are the same length in Fig. 263. The top side is not the same length as the bottom side in Fig. 264. The line *A-B* in Fig. 263 is called the neutral axis of the plate. It is exactly in the center of the thickness, and it is the same length as the top and bottom sides. In Fig. 264 something has happened, for the top side, the neutral axis, and the bottom side are all of different lengths. It is the same plate, but the top side is shorter and the bottom side is longer than the measurements at the same places in Fig. 263. The bending of the plate has caused the top side of the plate to "upset" (get shorter) and the bottom side to "stretch" (get longer). The length of the neutral axis is the same in both Figs. 263 and 264.

Calculating the Length

To obtain the correct length of a plate which will form a cylinder of a certain diameter, proceed as follows:

Multiply the inside diameter plus the plate thickness, by 3.1416. (3.1416 is called Pi.) It is the ratio of the circumference to the diameter; that is, any circumference is 3.1416 times as long as the diameter.

The plate thickness is added to the diameter because the upset in the plate equals the difference between the length of the plate surface and the neutral axis after the plate is rolled.

The diameter of the cylinder in Fig. 261 is 36″.

36″ + 3/8″ = 36 3/8″ or 36.375″ (The 3/8″ has been reduced to a decimal.)

Multiply 36.375 by 3.1416

$$\begin{array}{r}
36.375 \\
3.1416 \\
\hline
218250 \\
36375 \\
145500 \\
36375 \\
109125 \\
\hline
114.2757000
\end{array}$$

Procedure

1. Square the rough plate and scribe center line. See Fig. 259, Job Sheet No. 1, Part VI.
2. Lay out length of the plate equal to the circumference of the neutral axis of the cylinder plus 3/8″, and lay out the width of the plate.
3. Lay out center lines (Fig. 265) to represent distances of one quarter and three quarters of the cylinder circumference.
4. Find the correct measurement of the diagonal distance of the layout.

   This is done by extracting the square root of the sum of the squares of one side and one end of the laid-out rectangle. See the appendix for the correct procedure.
5. Set the trammels to the distance found in Step 4 and check the corner-to-corner distance of the layout. If found correct, proceed. If not correct, the work must be done again.
6. Center-punch-mark the center lines and the corners of the layout as shown in Fig. 265.
7. Place a center-punch mark on each corner of the layout, one inch from the planing lines (border lines).

This center-punch mark is called a witness mark, and it is used as a poin from which to check the work of the planer mechanic when the plate comes bacl from the plate planer.

8. Send the plate to the plate planer to be machined to the line, and beveled on th ends which are to be welded.
9. Check the plate planer's work when the plate is returned.
10. If approved, send the plate to be set for rolling.

QUESTIONS

1. Where on the plate can the layout man find the manufacturer's number plainly stamped?
2. Explain what is meant by "neutral diameter".
3. What is the neutral diameter of a cylinder of the following dimensions: ½″ thick, 40″ I.D., and 41″ O.D.?
4. State the value of Pi (or π).
5. What dimensions are used to find the length of a plate (circumference of a cylinder) which is to be rolled into cylindrical form when the inside diameter is given?
6. How is the length of a plate calculated when it is to be rolled into cylindrical form and the outside diameter is given?
7. Explain the procedure for laying out center lines on a plate.

JOB SHEET NO. 3
TO LAY OUT CENTER LINES ON A FLANGED DISHED HEAD

General Information

The flanged dished head, shown in Fig. 266, has a nozzle welded on the exact center of the outside of it. In order that the center of the head may be located, two lines at right angles are scribed across from the edge of the flange on one side to the edge of the flange on the opposite side. A straightedge is used to scribe these lines. The circumference of the head must be divided into four equal parts, and the dividing lines must be marked on the edge of the flange at these four points, each one equidistant from the two adjoining it. Two of the points are used to align the straightedge with the points across the head in one direction. The other two points at right angles to the first two are used to align the straightedge across the head at right angles with the first position. This operation must be very carefully carried out to make sure that the intersection of the two lines comes on the exact center.

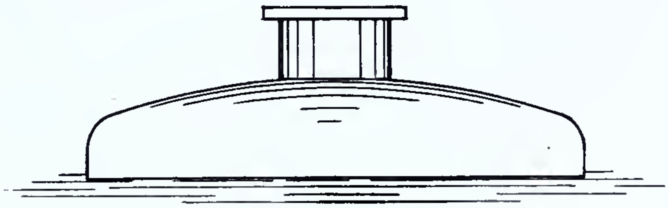


Fig. 266 — *Flanged Dished Head with Nozzle*

Fig. 267 — *Dividing the Circumference into Four Equal Parts and Marking the Divisions*

Tools and Equipment

1. 1 pair of trammels and stick
2. Combination square
3. Ball-peen hammer
4. Center punch
5. Light metal straightedge
6. 50-ft. steel tape
7. Two small C clamps
8. Marking brush

Materials

Paint pot　　Soapstone

Procedure

1. Find the circumference of the outside diameter of the dished head shown in Fig. 266.

   The circumference is equal to (π) pi x the outside diameter, that is, 36¾″ x 3.1416, or 9′ 7-7/16″.

2. Divide the circumference by 4 . The quotient is 2′ 4-55/64″.

3. Fasten the steel tape to the outside circumference of the head with small C clamp
4. Mark with soapstone on the dished head opposite the graduation on the stee tape at 2′ 4-55/64″.
5. Mark with soapstone on the dished head opposite the graduation on the stee tape at 4′ 9-23/32″.
6. Mark with soapstone on the dished head opposite the graduation on the steel tape at 7′ 2-37/64″.
7. Mark with soapstone on the dished head opposite the graduation on the steel tape at 9′ 7-7/16″, or at the end of the loop on the steel tape.

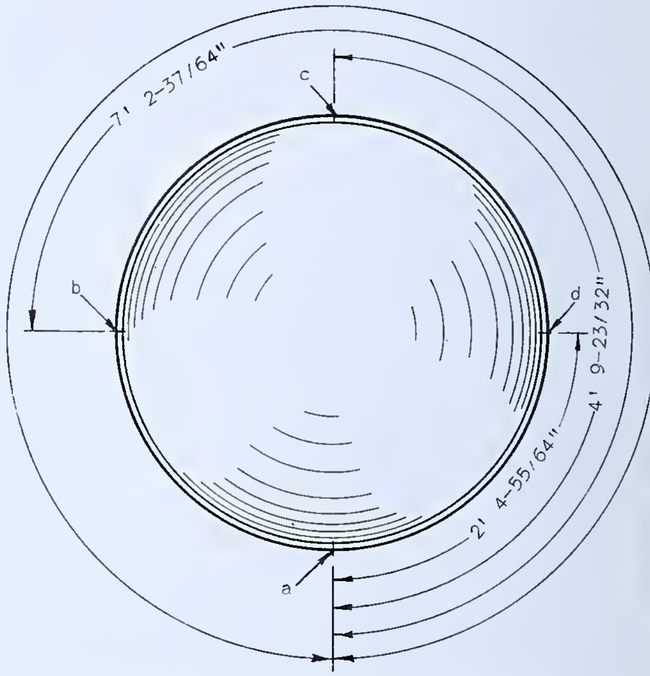


FIG. 268 — *Four Equal Spacings*

The markings should appear at regular intervals as shown in Fig. 268. The dished head is lying upside down on the rounded side as shown in Fig. 269. The steel tape is shown fastened temporarily to the flanged dished head with C clamps. The mark *a* at the end of the loop shown in Fig. 268 is opposite the C clamp in Fig. 269 and cannot be seer The mark *c* in Fig. 268 is on the opposite side of the head in Fig. 269 and car not be seen. The mark *d* in Fig. 268 is opposite the C clamp on the left in Fig. 26 and cannot be seen. The mark *b* in Fig. 268 is opposite the C clamp on the right i Fig. 269 and cannot be seen.

FINDING THE CORRECT MEASUREMENTS ON THE STEEL TAPE

For the sake of clarity, the correct markings were given in Steps 4 to 7. The ex planation of the method of determining the markings for locations follows:

Since the markings must be made at regular intervals of one fourth of the circumference of the outside diameter of the head, the first mark is made the distance of one fourth of the length of the circumference measured from the end of the loop on the steel tape (mark *b*), 2′ 4-55/64″.

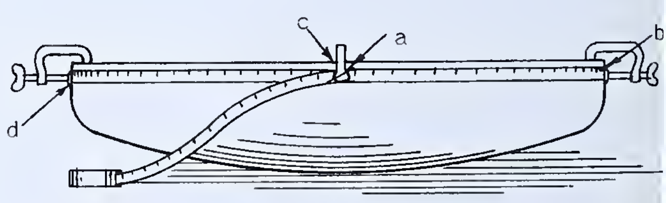


FIG. 269 — *Marking Off Four Equal Divisions on the Dished Head*

Since the next mark must be at a point opposite the starting point (halfway around the head), it is made the distance of one-half the length of the circumference measured from the end of the loop on the steel tape (mark *c*), 4′ 9-23/32″.

Since the next mark must be at a point opposite to the first marked measurement (*b*) or three fourths of the way around the head, it is made the distance of three fourths the length of the circumference measured from the end of the loop on the steel tape (mark *d*), 7′ 2-37/64″.

8. Use the combination square as shown in Fig. 270 and mark with soapstone the line shown at *a* which registers with the mark made at *a* in Step 7.

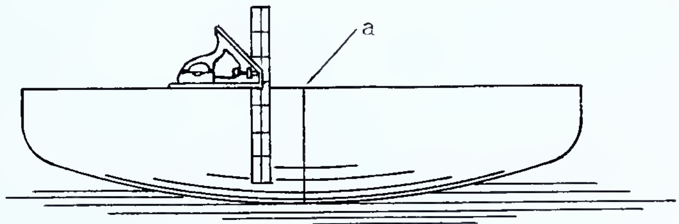


FIG. 270 — *Step* 8

9. Continue to use the combination square as in Step 8 and mark lines through the other three points at *b*, *c*, and *d*.

   Remove the C clamps and steel tape.

10. Set the combination square to 3″. Mark with soapstone an intersection line on the lines marked in Steps 8 and 9 as shown in Fig. 271.

    Turn the head over to rest on the flange.

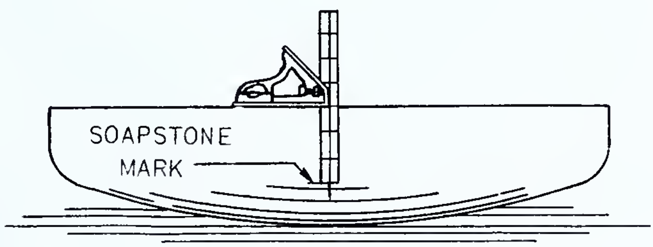


FIG. 271 — *Step* 10

11. Make a center-punch mark on the intersections made in Step 10. (Fig. 272).

    Since the flange on the dished head measures 3″ from the edge of the flange to the tangent line (round corner where the flange meets the dished surface), the center-punch mark will be almost on the round corner.

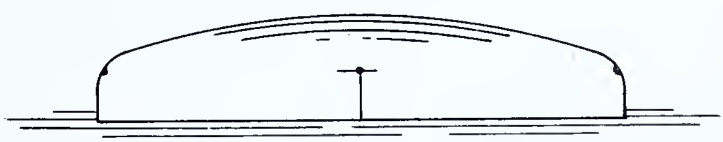


FIG. 272 — *Step* 11

12. Set the trammels to about half the diameter (18″) of the head.

13. Place one trammel point consecutively in each center-punch mark made in Step 11, and scribe an arc near the center of the head as shown in Fig. 273.

14. Use the rule and soapstone to mark diagonal lines through the intersections of the arc as shown in Fig. 274.

15. Make a center-punch mark on the intersection of the two diagonal lines as shown in Fig. 274.

16. Obtain a strip of light metal about 2″ wide, with a straight edge and long enough to reach from the edge of the flange on one side of the head, across the dished surface, and down to the edge of the flange on the opposite side. Block up the head far enough from the floor to allow the use of C clamps.

17. Clamp one end of the strip with the straight edge cutting one of the center-punch marks made in Step 11.

18. Carry the strip across the center of the dished head and down to the opposite flange and clamp it fast with the straight edge cut-

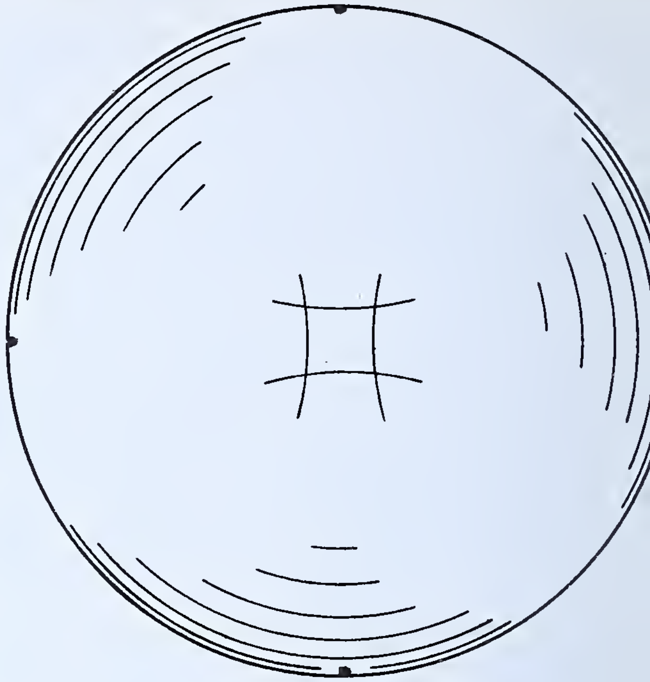


FIG. 273 — *Step* 13

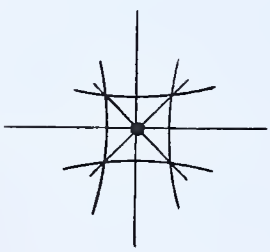


FIG. 274 — *Steps* 14 *and* 15

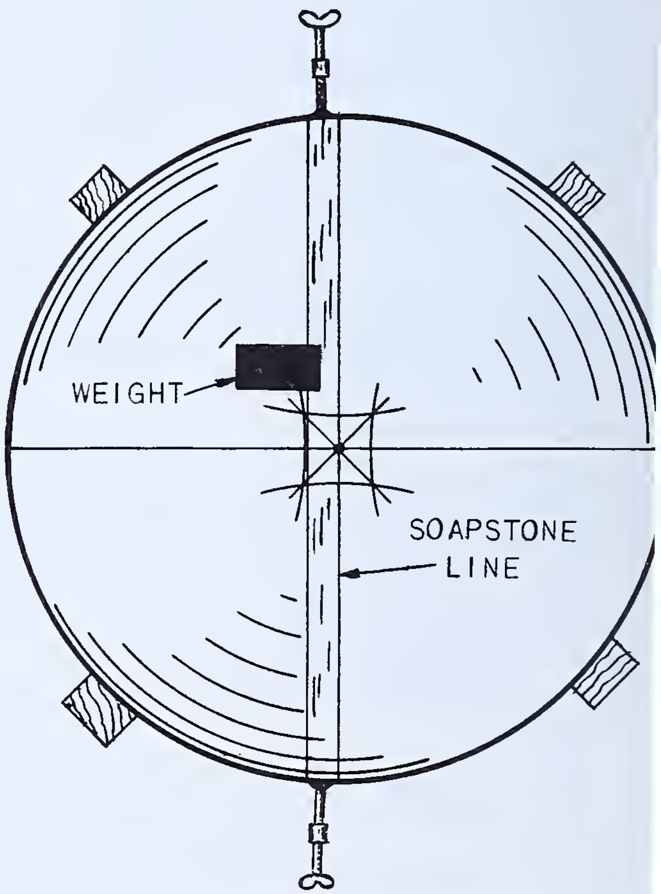


FIG. 275 — *Steps* 19 *to* 22

ting the center-punch mark opposite the one mentioned in Step 17.

Pull the metal strip tightly to the surface of the head before clamping.

19. Place the straight edge of the metal strip to cut the center-punch mark in the center of the head. (Fig. 274.).

20. Place a weight on top of the metal strip to hold it securely in place.

21. Mark with soapstone along the straight edge of the metal strip as shown in Fig. 275.

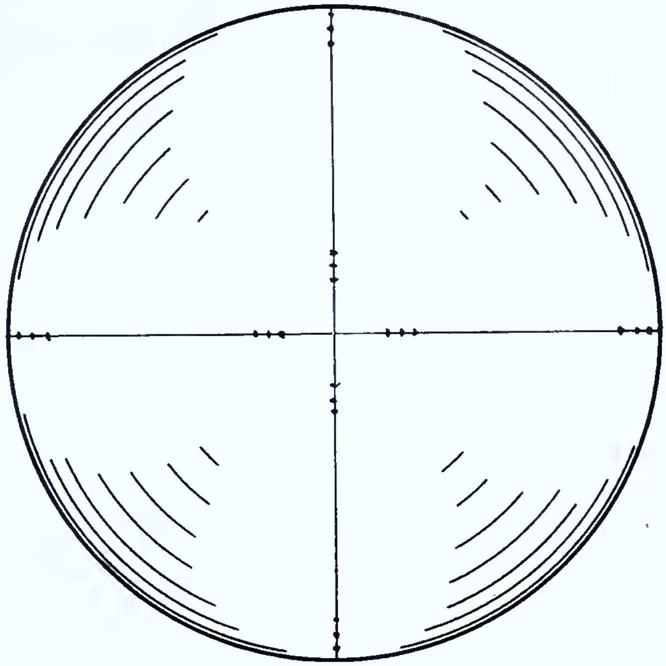


FIG. 276 — *Step* 23

22. Remove the metal strip, and proceed to mark a similar line through the center of the head and in line with the remaining center-punch marks on the flange.

23. Make center-punch marks on the center lines as shown in Fig. 276.

QUESTIONS

1. **Why is a weight used on the straight edge of the metal strip at the center-punch mark in the center of the head?**

2. **What is the purpose of the center lines?**

3. **Why are the groups of three center-punch marks made on the center lines?**

JOB SHEET NO. 4
TO LAY OUT A DOME

General Information

The dome shown in Fig. 277 is cylindrical in shape with the bottom end cut out to fit the outside diameter of the cylinder and with the top end cut square. A hinged cover is fitted to the top end after the rest of the work is completed.

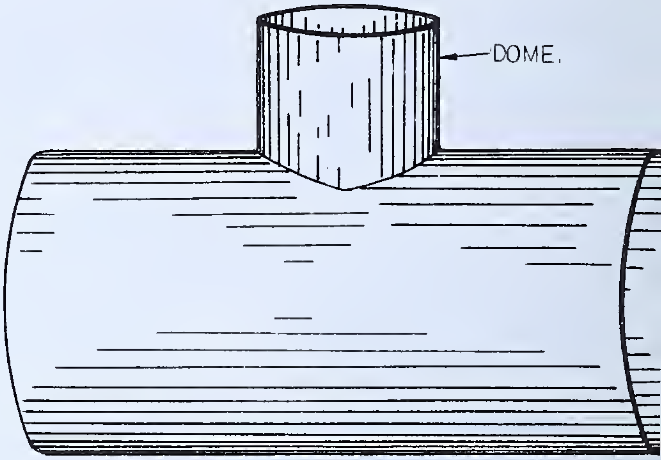


Fig. 277 — *A Dome Welded to a Round Tank*

The dome and the round tank should be considered as two cylinders of different diameters. The inside diameter of the small cylinder is 18″. The outside diameter of the large cylinder is 3′ 5¾″. The thickness of both cylinder wal is ⅜″. The flat plates from which the cylinders are made are laid out, the lines o which the curved shapes are to be cut are marked with the center punch, the plate burned along these lines, and the plates are rolled to form the required sizes c cylinders. After the rolling, the cylinders are aligned (as outlined in Job Sheet N 3, "Shop Fabricating"), and welded along the seam.

Tools and Equipment

1. Scriber
2. Straightedge
3. Trammels
4. Dividers
5. 6-ft. folding rule
6. 1-24″ steel square
7. Hammer
8. Center punch
9. 2 clamps
10. Tin shears
11. Measuring wheel

Materials

Soapstone
Paint
Marking brush
Adhesive tape

Procedure — To Lay Out Template for Dome

1. Lay out the outside diameter (41¾″) of the large cylinder on *C a-b* (48″ long as shown in Fig. 278.

   The full line is the neutral axis. The dotted lines represent the inside and tl outside of the cylinder.

2. Erect a perpendicular on the line *a-b* at *o*. Make the perpendicular 40″ long through *o-x-d-o* to *t* (the top of the dome diameter).
3. With *d* as a center, scribe the neutral diameter (9-3/16″ r.) of the dome.
4. Divide one quadrant of the dome circle into five parts as shown in Fig. 278.
5. Project the intersecting points of the radii down to the outside diameter of the large cylinder.

   The projected lines must be parallel with the center line *o-t*.
6. Obtain a piece of template paper 36″ wide and 60″ long.

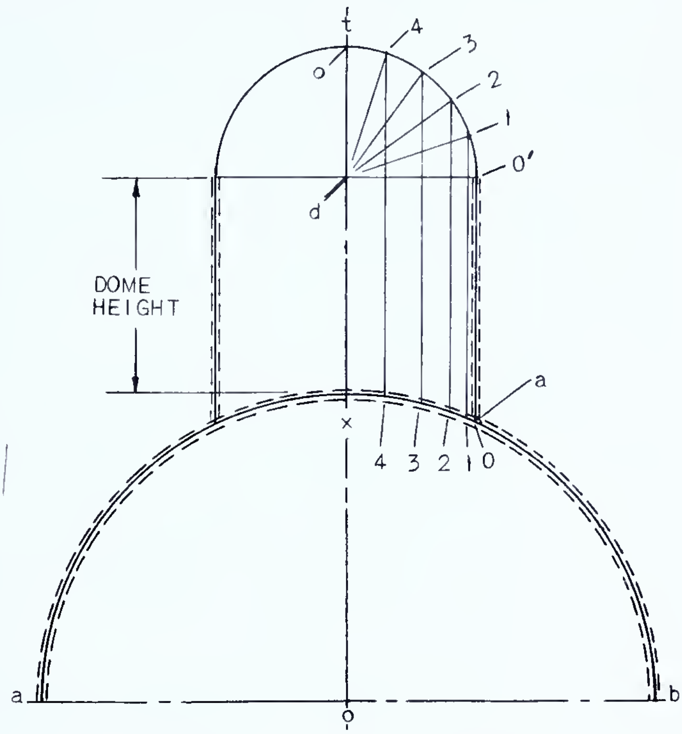


FIG. 278 — *Layout of Cylinders*

7. Find the circumference of the neutral diameter of the dome.

   The neutral diameter is $18\frac{3}{8}''$.

   The circumference is $18\frac{3}{8}''$ x 3.1416, or 57.726″ (that is, approximately $57\frac{3}{4}''$).
8. Lay out on the template paper a line (*m-n*, Fig. 279) about 2″ from one edge and the full length of the paper.

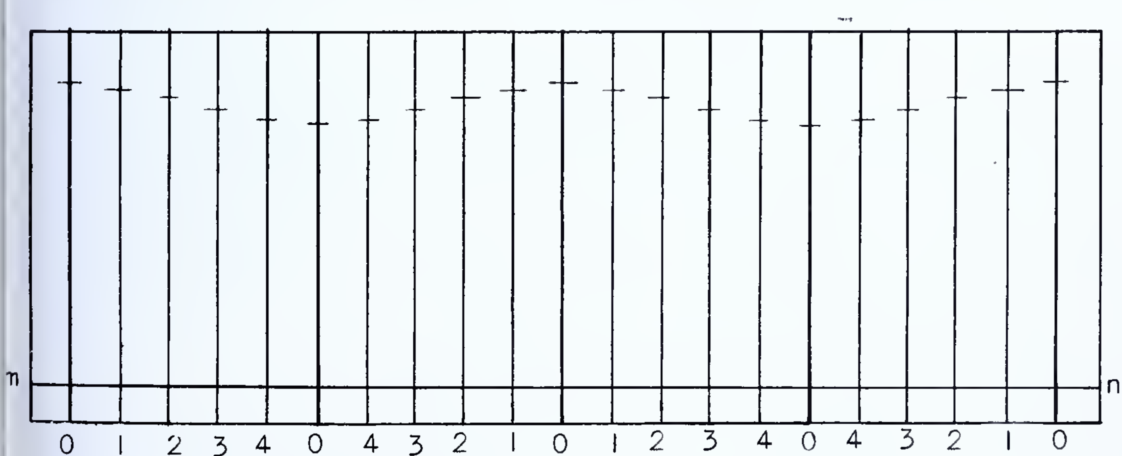


FIG. 279 — *Beginning the Layout for the Dome*

9. Square a vertical center line halfway between *m* and *n* on line *m-n*.
   Use the trammels to erect the perpendicular or use the steel square.
10. Lay off from this center line to the right and to the left a distance equal to ha of the neutral circumference of the dome (28⅞″).
11. Bisect these distances and lay off a distance from the center line equal to on fourth of the neutral circumference of the dome (14-7/16″).
12. Square vertical lines through the points laid off in Steps 10 to 11.
    The vertical lines must be parallel with the center line.
13. Divide each of these four spaces into five equal spaces, and square vertical lin across the template paper as shown in Fig. 279.
14. Set the trammels (Fig. 278) to distance *o-a* from the top of the dome to th intersection of the line with the O.D. of the large cylinder at *a*.
15. Transfer this distance to the template paper (Fig. 279) on the central center lin *o* and on the two outer lines *o-o* and scribe a short line to intersect the cent line at the top of the paper.
16. Set the trammels (Fig. 278) on line 1-1 from the top of the dome to the inte section of the line with the O.D. of the large cylinder (first point to the left point *a*).
17. Transfer this distance to the template paper (Fig. 279) on the center lines mark *1* and on the outer lines marked *1* and scribe a short line to intersect the respecti lines at the top side of the paper.
18. Continue setting the trammels to the distances in Fig. 278 and transfer them the template paper as shown in Fig. 279.

    The template paper should now have the appearance of Fig. 279. The inte sections of the short lines with the long lines indicate the points through whi a curved line must be scribed.

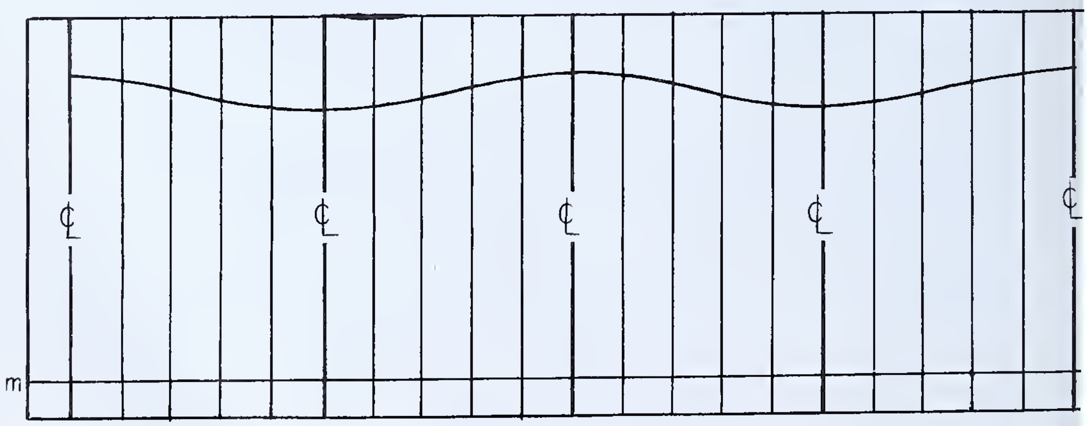


FIG. 280 — *Intersections Connected by a Smooth Line*

19. Scribe a line from one intersection to the next one so that the completed line will flow evenly from end to end of the template paper as shown in Fig. 280.

20. With the tin snips cut the template paper along the curved line, along the straight base line *m-n*, and along two outer lines. The template will have the appearance of Fig. 281.

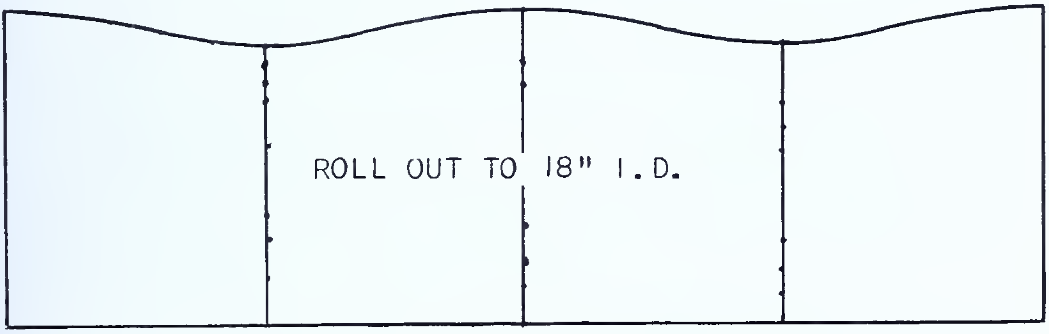


FIG. 281 — *The Completed Template*

21. Clamp the template on the 3/8″ plate and mark around it with a soapstone pencil.

22. Center-punch all center lines and all border lines.

23. Mark the plate with paint: ROLL OUT TO 18″ I.D.

TO LAY OUT TEMPLATE FOR DOME OPENING.

1. Obtain a piece of template paper about 48″ square.
2. Scribe two center lines (Fig. 282) at right angles.
3. Wheel the curved line which represents the O.D. of the large tank, and find the distance from center line *o-t* to the O.D. of the dome at *a*. See Fig. 284.

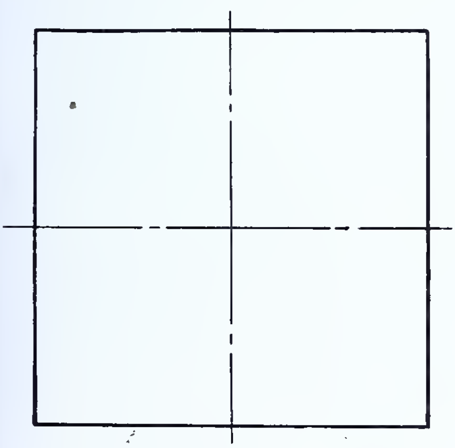


FIG. 282 — *Beginning of Layout for Dome Opening in the Large Cylinder*

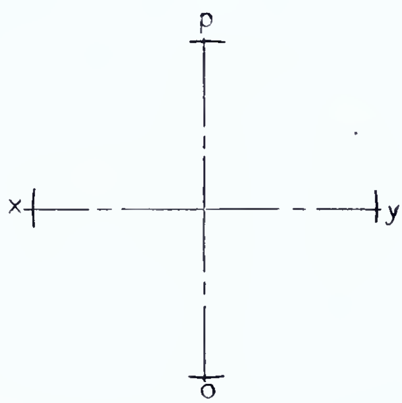


FIG. 283 — *Layout of Working Limits*

4. Set the trammels to the distance found in Step 3.

5. With one trammel point set in the intersection of the two center lines shown in Fig. 282, scribe two short arcs at x and y as in Fig. 283.

6. Set the trammels to the distance from center line o-t to O.D. of dome as at b in Fig. 284.

7. With one trammel point set in the same intersection used in Step 5, scribe two short arcs o and p as in Fig. 283.

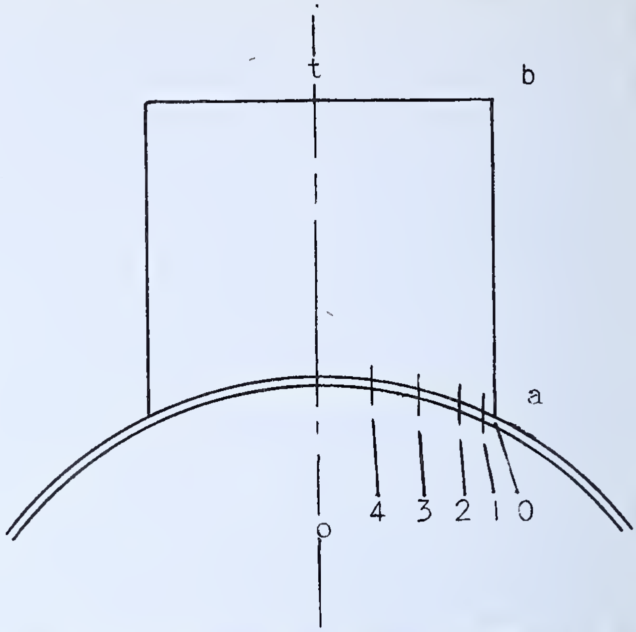


FIG. 284 — *Showing the Points at Which the Dome Meets the Large Cylinder*

The distance x-y in Fig. 283 is the distance measured with the wheel on th curve from the center line o-t to point a in Fig. 284. The distance o-p in Fig. 28 is the diameter of the dome measured in a longitudinal direction on the larg cylinder. The points shown in Fig. 285 having been established, the curve fc the down opening in the large cylinder can be plotted.

8. Wheel the curve from the center line o-t (Fig. 284) to the intersecting line 4.

9. Set the dividers to this distance and transfer it to the template paper on the cei ter line x-y, Fig. 285.

With one divider point placed on the intersection of center lines o-t and x- scribe a short arc across center line x-y to locate the intersecting points of line 4 with center line x-y in Fig. 285.

10. Wheel the curve from line 4 to line 3 (Fig. 284).

11. Set the dividers to this distance and transfer it to the template paper immediately next to the distance stepped off in Step 9.

This point is the intersection of line 3 with center line x-y in Fig. 285.

12. Proceed to wheel the outer distances in Fig. 284 and transfer them to the template paper as in Fig. 285 as in Steps 9 and 11.

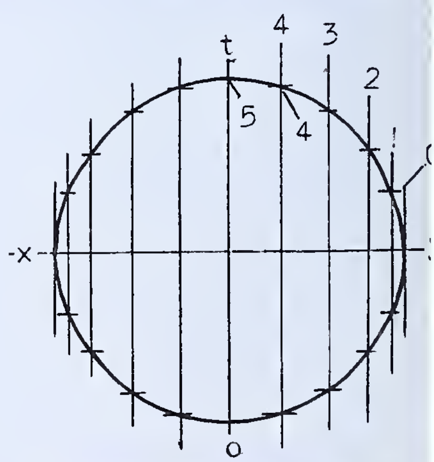


FIG. 285 — *Template Ready to Cut Out*

13. Step off the spaces on center line *x-y* to the left of center line *o-t*.

14. Scribe lines through the intersections and parallel to center line *o-t*.

15. Scribe a line completely around the template from one intersection to the next one so that the completed line will flow evenly as shown in Fig. 285.

   a. Place one leg of the trammels on intersection *d* (Fig. 278) and adjust the other leg to point *x*.

   b. Transfer this distance to Fig. 285. Set one leg of the trammel on the intersection of line *x-y* and line *o-t*. Scribe a short arc 5 at the top of center line *o-t*.

   c. Repeat step *b* at the bottom of center line *o-t*.

   d. Place one leg of the trammels on intersection of line 4 and adjust the other leg to the top of dome in Fig. 278.

   e Transfer this distance to Fig. 285. Set one leg of the trammel on the intersection of line 4 and center line *x-y* in Fig. 285 and scribe a short arc 4 at the top of line 4.

   f. Repeat Step *e* at the bottom of line 4.

   g. Continue to set the trammels to the other distances in Fig. 278 and transfer them to Fig. 285.

   h. Scribe a curved line through the intersections of the vertical lines and the arcs.

   The template will now have the appearance of Fig. 285.

16. Lay the template on the cylinder so the lead lines will register with the center lines on the template.

17. Hold the template securely in place with adhesive tape and center-punch through it on the curved line at intervals of about 2″.

18. Remove the template.

19. Mark with paint inside of the center-punched circle, BURN OUT, and mark with short dashes around the circle, as shown in Fig. 286.

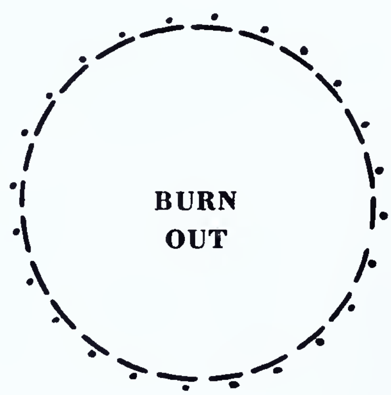


FIG. 286 — *Layout Marked for Opening to be Burned Out*

QUESTIONS

1. Why is it necessary to make a full-sized layout?
2. What is the reason for spacing the half-circle?
3. Explain the reason for multiplying the neutral diameter by 3.1416.
4. State the purpose of a template.
5. For what purpose are the trammels used?
6. Why are the spaces numbered?
7. What is a dome?
8. Explain the reason for using the neutral diameter when finding the circumference of the dome.
9. Explain how the template is used for laying out the hole in the dome.
10. State how the burner knows where to burn out the opening for the dome.

JOB SHEET NO. 5
TO LAY OUT A CONE FRUSTUM

General Information

Cylindrical tanks are sometimes finished off with cone-shaped ends. A tank with conical-end sections is shown in Fig. 287. The parallel section of the job is made up

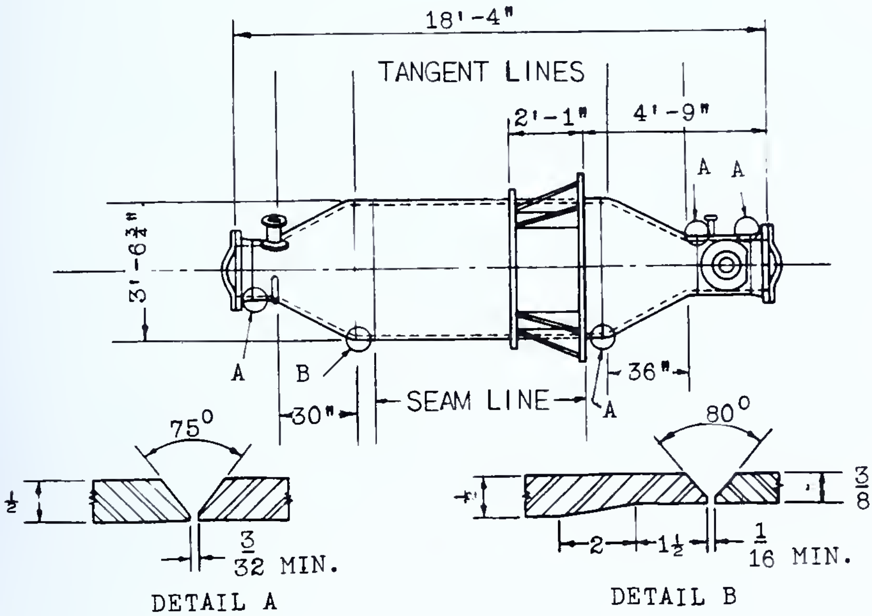


Fig. 287 — *Pressure Tank with Control End Sections*

first; then the conical sections are laid out and fitted to it. It will be seen that the cones shown in Fig. 287 are 36″ I.D. (inside diameter) at the base and 18″ I.D. at the neck. (The neck is at the point which corresponds with the small diameter of the frustum of a cone.) The metal thickness is ⅜″. The height of the frustum of this conical shape is 30″ including the tangent-to-end distances.

Making the Layout

All similar layouts are made first on template paper. The circumference of the base of the cone can be found on the bill of material. The width of the template paper must be about three inches more than the cir-

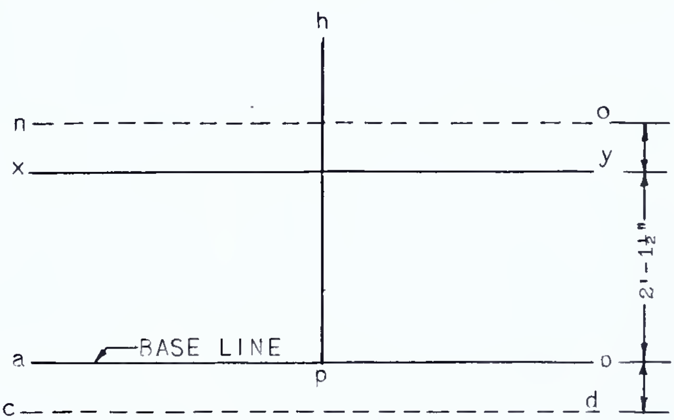


Fig. 288 — *Template-Paper Layout*

cumference of the cone base to allow for variation. The length of the template pa is found after the layout is partially completed. This length is never made any lon than the width.

The template paper is laid on the layout-loft floor and held in position with n cellaneous blocks or pieces of scrap.

Scribing the Base Line for the Layout

A base line *a-b* is scribed at a distance of approximately 12″ from the front e of the template paper. Fig. 288. Use a steel straightedge to scribe the base line. perpendicular line is scribed from the base line as in Fig. 288, at *p-h*. The length the perpendicular must be about six inches more than the circumference of the co base.

A line *n-o* is scribed parallel to the base line ***a-b***, and a second line ***c-d*** is scrib parallel to the base line *a-b*. *See* Fig. 288. The distance between the two sets of parallel lines is the height of the cone frustum from tangent line to tangent line. The tangent lines are shown at *x-y* and *a-b*, Fig. 289. The tangent line is the point at which the flange line breaks away from the true lines of the sides of the cone frustum as shown by the intersections 1, 2, 3, and 4. The line *x-y* in Fig. 288 is scribed parallel to the base line *a-b* and 36″ from it. This 36″ distance is the true height of the cone frustum and is also the distance from tangent line to tangent line. The tangent lines are shown in Fig. 287.

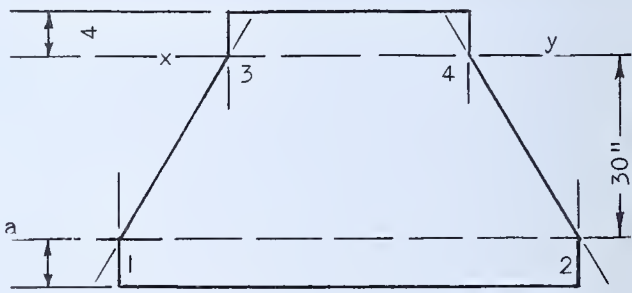


Fig. 289 — *Tangent Lines*

Another illustration of the template paper layout is shown in Fig. 290. There are some additional lines and reference letters on this layout. Measuring from center line *p-h* on line *x-y*, step off with dividers a distance of 9-3/16″. This distance is half the neutral diameter

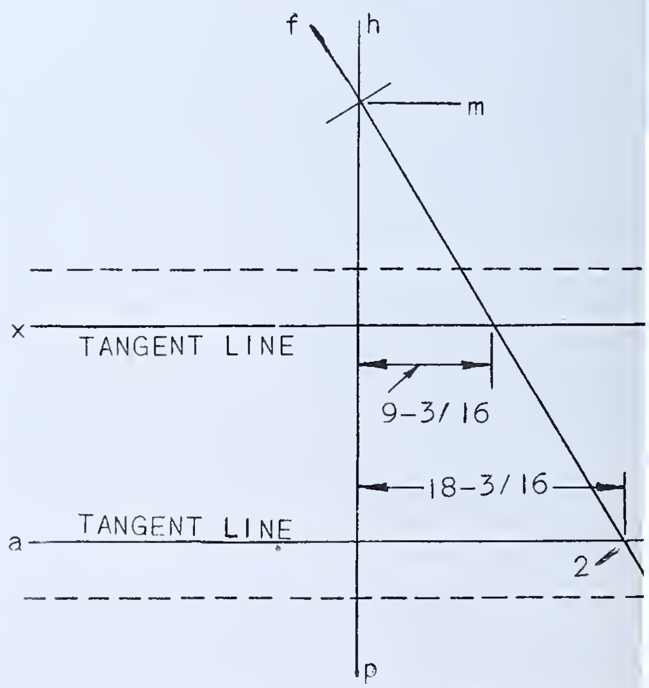


Fig. 290 — *Layout for Cone Side*

of the small end of the cone frustum. The base of the cone is 36⅜″ neutral diameter and half of this distance is 18-3/16″. Step this distance off from the center line on line *a-b* as shown. Through the intersections thus obtained scribe a line *f-f* which is the angle of the cone with the center line. The point *m* at which line *f-f* cuts line *p-h* is the center from which the radius of the developed base of the cone is struck. It is called the apex of the cone.

The trammels are set with one point at *m* and the other point at 2 on line *a-b*, and an arc is scribed as shown in Fig. 291. Repeat this at points 1, 3, and 4 using the same center *m*.

The circumference of the neutral diameter of the base of the cone is found by multiplying 36⅜″ by pi (36.375 x 3.1416). The product is 114.275, or 114¼ inches.

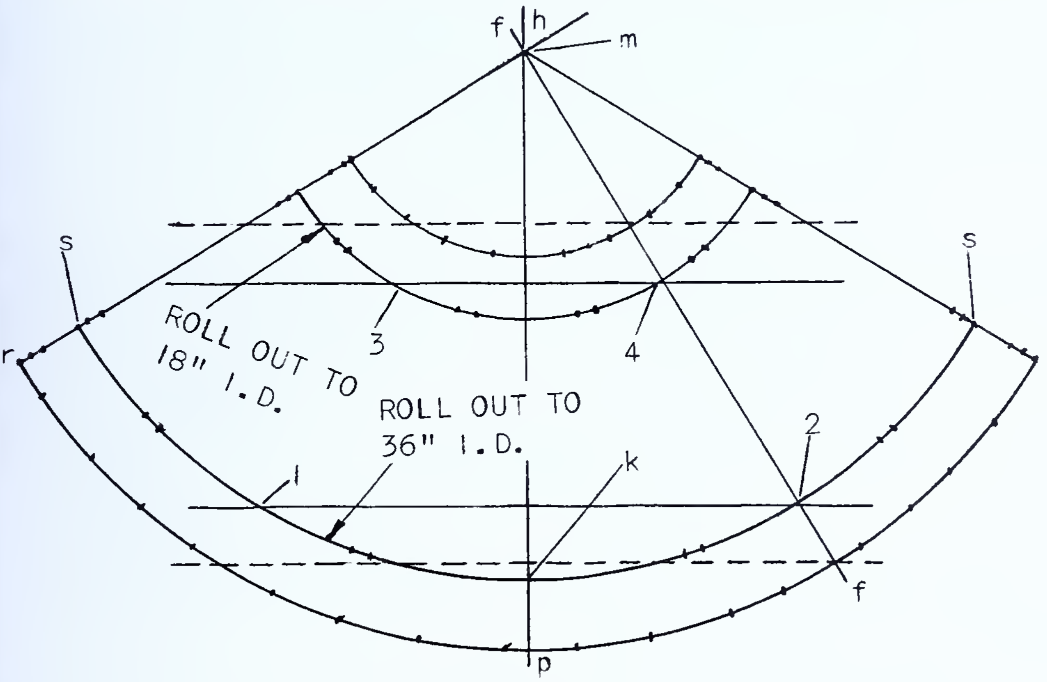


Fig. 291 — *Developing the Cone Layout*

This distance must be laid off on line *r-r* Fig. 291. It is necessary to lay off only half this distance since both sides of the template are the same.

With the measuring-wheel pointer on the center line at *k*, wheel half the distance of the circumference (57⅛″) and scribe a short line at *s*. Repeat this on the opposite side of the template. With a straightedge, scribe a line through *s* and *m* and extend the line at the bottom to cut the arc *r-r*. Repeat this on the opposite side of the template.

The template is cut out on the lines *m-r* and *r-r*. After the template is cut out, it is laid on the steel plate in a position which will allow the greatest number of pieces to be cut out. With the template correctly located, it is clamped to the steel plate with

thumb clamps. The center punch and the hammer are used to center-punch mark through the template and onto the steel plate as shown in Fig. 291.

The single punch marks about 3″ apart indicate that the plate is to be burned o that line. The double punch marks about 6″ apart indicate that the steel is to b flanged on that line. The triple punch marks close to the arc intersections indicat that the steel is to be planed and beveled for welding on that line. The plate is marke with white paint: TO BE ROLLED OUT TO THE INSIDE DIAMETERS. This mark ing is shown in Fig. 291 as follows:

Roll out to 18″ I.D.

Roll out to 36″ I.D.

The painted markings are always made on the surface that has been center punche This is done so that all the center-punch marks and paint markings may be seen clearl by the inspector after the cone is rolled. When the blank is correctly rolled out, th beveled edges of the blank come together to form a cone frustum of the correct siz

Tools and Equipment

1. 6′ folding rule
2. Measuring wheel
3. Trammels
4. Center punch
5. Ball-peen hammer
6. Tin snips
7. Marking brush
8. Thumb clamps
9. Straightedge
10. Scriber
11. 12″ dividers

Materials

Marking paint — Soapstone

The work for laying out a cone may be summarized as follows:

Procedure

1. Study the blueprint carefully to obtain the dimensions and other informatio needed to lay out a cone.

2. Obtain a piece of template paper large enough for the layout.

   The length of the template paper corresponds to the circumference of the co plus 12″, and the width to the height of the cone plus 24″. For other sizes cones, the dimensions of the template paper are computed accordingly.

3. Lay out a base line the entire length of the template paper and approximate 12″ from the bottom edge.

4. At the center of the base line erect a perpendicular to extend the full height the template paper.

5. Scribe a line 4″ from, and parallel to, the base line the full length of the templa paper.

6. Scribe a line 36″ from, and parallel to, the base line for the full length of the template paper.

   The base line is the tangent line for the bottom end of the cone, and the line 36″ above it is the tangent line for the top end of the cone frustum. See Fig. 290.

7. Scribe a line 40″ from, and parallel to, the base line for the full length of the template paper.

   See Fig. 288 for the arrangement of the lines (Steps 5, 6, and 7).

8. On the upper tangent line, measure from the center line to the right a distance (9-3/16″) equal to half the neutral diameter of the small end of the cone frustum.

9. On the lower tangent line, measure from the center line to the right a distance, (18-3/16″) equal to half of the neutral diameter of the bottom of the cone.

10. Through the two points found in Steps 8 and 9, scribe a line (*f-f*) cutting the center line and the bottom edge of the template.

    The point where this line cuts the center line is the apex of the cone and the center from which the arcs are scribed. The line itself represents the side of the cone.

11. Set one leg of the trammels in the apex of the cone, and set the other leg on the lower tangent line at the intersection with the side of the cone. Scribe an arc from one side of the template to the other. This arc is the base circle of the cone. See Fig. 291, "Developing the Cone Layout".

12. With the same center, scribe other arcs cutting the intersection of the side of the cone with each of the remaining parallel lines, as in Steps 5, 6, and 7.

    These arcs (indefinite in length) are scribed from one side of the template paper to the other.

13. With the measuring-wheel pointer on the intersection of the center line with the cone-base circle, measure off on the arc half the circumference of the neutral diameter of the cone, in this case 57⅛″. Mark with soapstone.

14. Repeat the procedure in Step 13 to the left, and mark with soapstone.

15. With the straightedge, scribe a line through each of the marks on the base circle and the apex of the cone. See Fig. 291.

16. Cut the template out on the outside lines all around.

17. Clamp the template on the steel plate in a position which will allow the greatest number of pieces to be cut out.

18. Center-punch-mark the burning line, the flange line, and the planed and beveled line.

    Single-punch-mark the burning line, double-punch-mark the flange line, and triple-punch-mark the planed and beveled line.

19. Remove template.

20. Paint the roll-out diameters on the steel plate at the top and bottom of the co frustum.
21. Mark pc. mk. on the plate as indicated on the blueprint.
22. Have the burner cut the plate to the lines as indicated.

QUESTIONS

1. **What is the purpose of a template?**
2. **Explain the reason for making a layout of the cone before developing the template shape.**
3. **How is the measuring wheel used when developing a template for a cone?**
4. **Where is the measurement found for the length of the arc *s-s* in Fig. 291?**
5. **Name the point which serves as a center for the several arcs which are scribed on the template?**
6. **What is meant by the term "tangent line"?**
7. **State the method used to hold the template in position while transferring the markings to the steel plate.**
8. **What means are used to transfer the template markings to the steel plate?**
9. **Explain the meaning of the single center-punch markings on the steel plate.**
10. **What is indicated by the triple center-punch markings on the steel plate?**
11. **The plate is marked "Roll out 36″ I.D.". What does this marking indicate?**
12. **On which side of the plate are all of the markings made Why?**

JOB SHEET NO. 6
TO LAY OUT A SQUARE-TO-ROUND TRANSFORMER

General Information

A square-to-round shape is shown in Fig. 292. This shape is often used to make the connection between a square section and a round section of a tank or other unit. The flat plate is laid out, center-punch-marked, and burned to the line. In that the material used is boiler plate and is not easily bent or formed in one piece, the shape is formed in two symmetrical halves which are then welded together to produce the required connecting piece.

Obtaining the Dimensions

The dimensions for this piece are found on the blueprint. This particular job is 36″ square inside of the base, 18″ inside diameter at the round end, and 24″ high. The thickness of the wall is ⅜″.

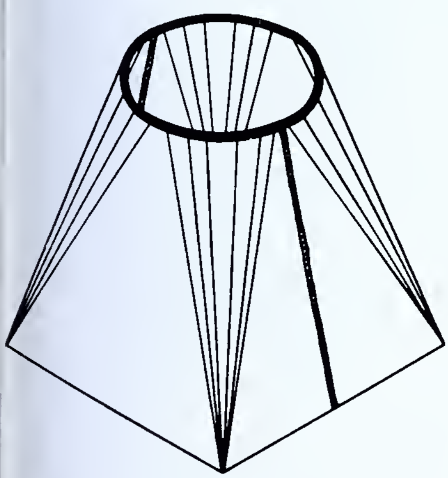


Fig. 292 — *Square-to-Round Transformer*

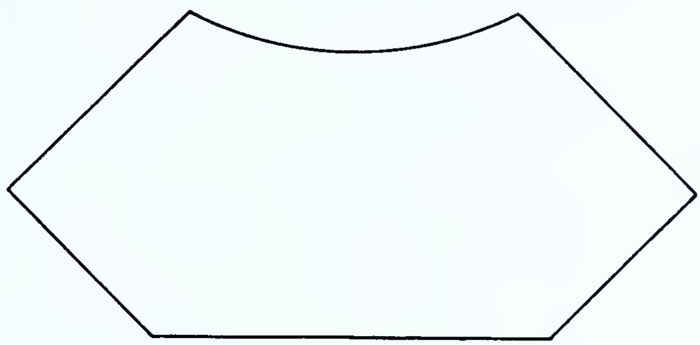


Fig. 293 — *Half of Square-to-Round Transformer Flattened*

Beginning the Layout

If the square-to-round shape shown in Fig. 292 were to be cut on the welded seams and flattened out, the flat piece would look like Fig. 293. There are certain rules to follow to make a layout of this shape on flat plate so that when the plate is formed it will take the shape shown in Fig. 292. The work involved and the rules which must be observed when making the layout are given below. The layout can be made on template paper, or it can be made directly on the steel plate. It is customary to make the layout on template paper and then transfer the principal markings to the steel plate.

Tools and Equipment

1. 1 6 Folding rule
2. 1 Steel straightedge, 7′ long
3. 1 Pair of dividers
4. 1 Set of trammels and trammel stick
5. 1 Steel scriber
6. 1 24″ steel square
7. 2 4″ C clamps
8. 1 Ball-peen hammer
9. 1 Center punch
10. 1 Marking brush
11. 1 Pair of tin shears

Materials

Soapstone
Paint pot
Template paper

Procedure

1. Make a full-sized layout as shown in Fig. 294.

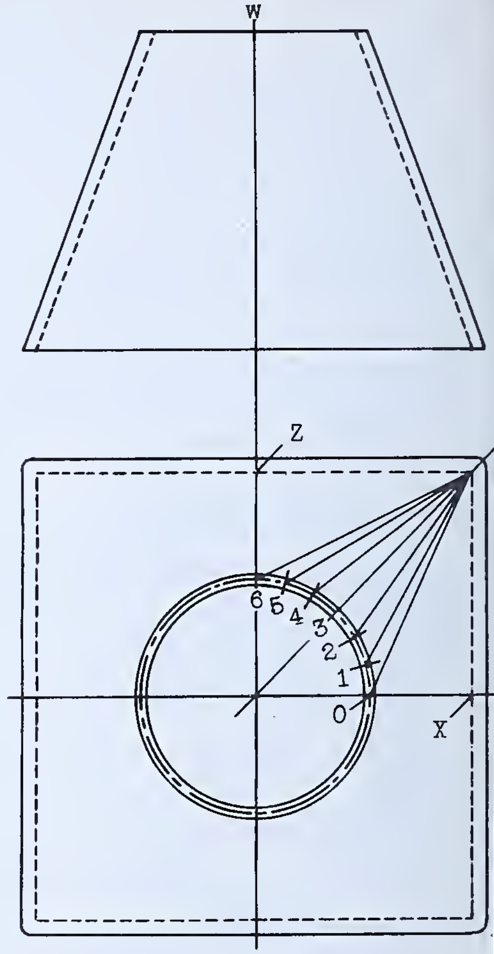


Fig. 294 — *Full-Sized Layout of Transformer*

2. Divide the circumference of the neutral diameter of the eighteen-inch-diameter end of the transformer into twenty-four equal spaces and use the spaces in one quadrant as shown in Fig. 294.

   More divisions than six will produce a more smoothly developed curved line. When larger diameters are involved, the spaces number as many as twelve. The number of divisions is a matter which is governed by the size of the job to be laid out.

3. Mark each dividing line as shown — 0, 1, 2, 3, 4, 5, and 6.

4. Scribe radial lines from point *y* to each of the numbered marks where they intersect the neutral diameter of the transformer circle.

5. Scribe a horizontal line 36″ long and on it erect a 30″ perpendicular (*x-w*) as shown in Fig. 295.

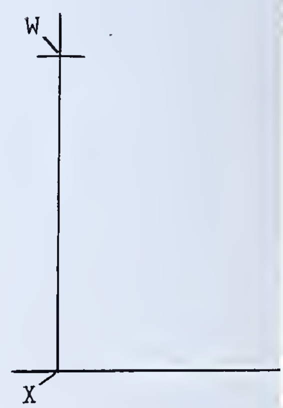


Fig. 295 — *Perpendicular Erecte on a Horizontal Line*

6. Scribe a short line across the perpendicular (*w*) which measures the vertical height (24″) of the transformer from the horizontal line.

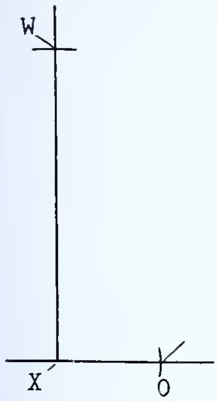


Fig. 296 — *Step* 8

7. Set the trammels to the distance *x-o* in Fig. 294.

8. Transfer this distance to the layout as in Fig. 296, at *x-o*[1].

9. Set trammels to the distance *y-o* in Fig. 294.

10. Transfer this distance to *x-o* as shown in Fig. 297.

11. Set the trammels to the distance *y-1* in Fig. 294.

12. Transfer this distance to *x-1* as shown in Fig. 297.

13. Set the trammels to the distance *y-2* in Fig. 294.

14. Transfer this distance to *x-2* as shown in Fig. 297.

15. Set the trammels to the distance *y-3* in Fig. 294.

16. Transfer this distance to *x-3* as shown in Fig. 297.

17. Note that the distances from *y* (Fig. 294) to *0, 1,* and *2* are the same as the distances from *y* to *6, 5,* and *4.*

18. Scribe lines from *w* to points *O′, 3, 4, 5,* and *6* as shown in Fig. 298.

19. Begin template layout at this point.

The instructions up to this point have covered the necessary steps to establish the center lines and construction lines which are to be used in making the actual template for the transformer.

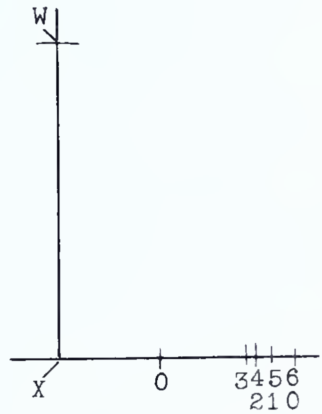


Fig. 297—*Steps* 10 *to* 16

20. Obtain a piece of template paper about 84″ long and about 48″ wide.

21. Scribe a straight line about 2″ from one edge and the full length of the template paper.

22. Erect a perpendicular *x-w* (use the steel square or the trammels) at the middle point of the straight line (*y-y*) as shown in Fig. 299.

23. Set the trammels to the distance *x-y* in Fig. 294.

24. Transfer this distance to the layout as shown in Fig. 299 at *y* and *y*.

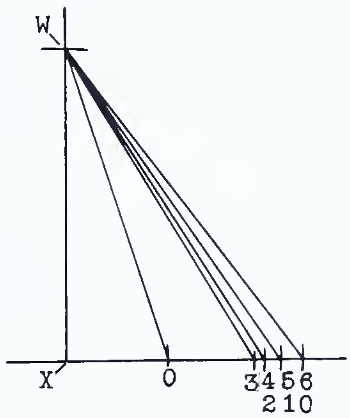


Fig. 298 — *Step* 19

25. Set the trammels to distance *w-6* in Fig. 298.

26. Transfer this distance to the layout *y-w* as shown in Fig. 299.

Distances *w-y* in Fig. 299 measure the same. The distance *w-y* in Fig. 299 is equal to the distance *w-6* in Fig. 298.

27. Set the trammels to distance *w-o′* in Fig. 298.

28. Transfer this distance to the template as shown at *x-o* in Fig. 300.

    Set one trammel point in the intersection of line *x-o* with the horizontal line (Fig. 300), and scribe an arc to cut point *o* on line *x-o*.

29. Set the dividers to distance *0-1* in Fig. 294.

30. Place one divider point in intersection *0* (Fig. 300) and scribe a short arc at *1*.

31. Set the trammels to distance *w-1* in Fig. 298.

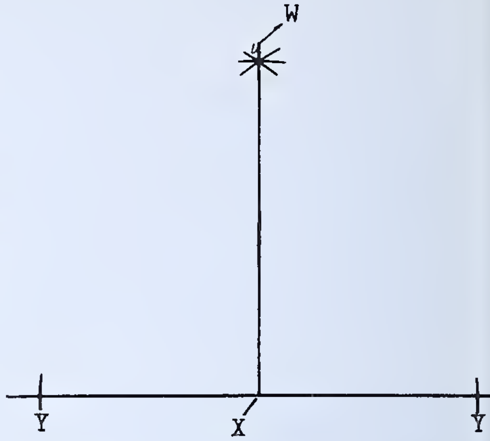


FIG. 299 — *Perpendicular Erected on Template as in Step 22*

32. Place one trammel point in the intersection (right-hand *y*) and scribe a line to cut the short arc scribed in Step 30.

33. Set the trammels to distance *w-2* in Fig. 298.

34. Place one trammel point in intersection (right-hand *y*) as before and scribe a short arc.

35. Set the dividers to distance *1-2* in Fig. 294.

36. Place one divider point in intersection *1* (Fig. 300) and scribe an arc to cut the arc scribed in Step 34.

37. Continue setting dividers and trammels to distances on Figs. 294 and 298 until intersections have been made from *0* to *6* as shown at the right and the left of the center line *x-o* in Fig. 300.

38. Set the trammels to distance *y-z* in Fig. 294.

39. Place one trammel point in intersection (right-hand *y*) and scribe an arc.

    Repeat this at the left-hand *y*.

40. Set the trammels to distance *o-w* in Fig. 298.

41. Place one trammel point in intersection of two arcs at 6 (Fig. 300) and scribe an

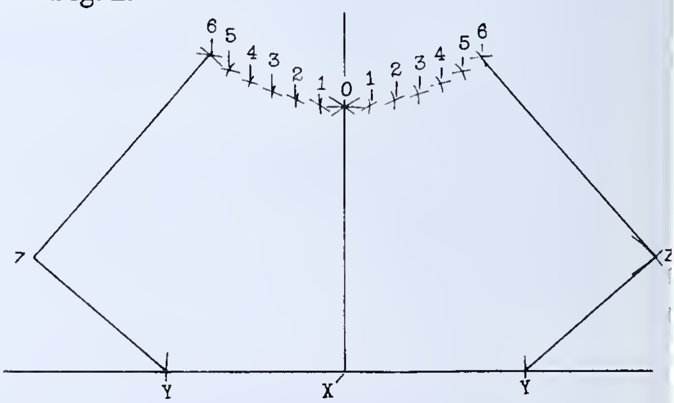


FIG. 300 — *Finding the Intersections for the Curve*

arc to cut the arc scribed in Step 39.

Repeat this at the left-hand *y*. The two arcs should intersect as at *z* in Fig. 300.

42. Scribe lines from *y* to *z* and from *z* to *6* at right and left sides of Fig. 300.

Lines *y-z* and *z-6* should check at right angles with each other if the work up to this point is correct. If the lines do not check at right angles, the work must be rechecked to find the error.

43. Scribe straight lines from *y* to *0* and from *y* to the rest of the intersections shown in Fig. 300.

44. Scribe a curved line to the right through the intersections *0, 1, 2, 3, 4, 5,* and *6* shown in Fig. 300.

45. Scribe a curved line to the left through the intersections *0, 1, 2, 3, 4, 5,* and *6* shown in Fig. 300.

46. Cut the template with the tin snips all around the curved line and along the straight boundary lines.

The template should appear as shown in Fig. 301. The radial lines which converge at *y* are the lines on which the plate is bent to form the transformer. The layout man marks the template with paint to indicate the number of pieces of steel plate which are to be laid out from the template. Since this template is only a half-pattern, two steel plates are required for the job.

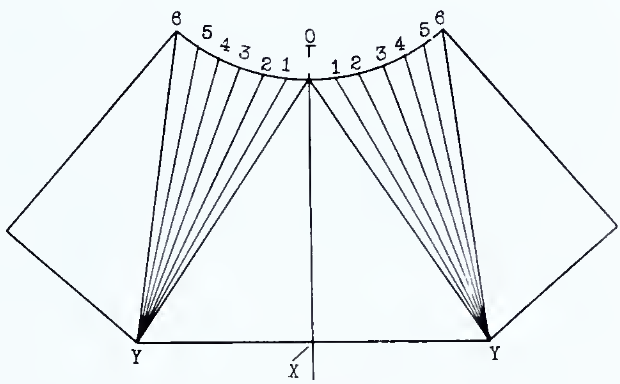


FIG. 301 — *Finished Template*

QUESTIONS

1. **Explain the reason for making a layout of this job.**
2. **Why is it unnecessary to divide the whole circumference of the round end of the transformer into spaces?**
3. **What is the purpose of trammels and dividers?**
4. **In what way can a 90° angle be used to check the accuracy of the layout?**
5. **Why are the neutral measurements of this job used as a basis for the layout work?**
6. **Explain the advantage of numbering the intersecting points and lines.**

JOB SHEET NO. 7
TO LAY OUT A CONE FRUSTUM BY TRIANGULATION

General Information

When a very large cone frustum must be laid out, it is not always possible or convenient to make the layout as was done in Job Sheet No. 5. In such cases the template curve and the curve limits are found by triangulation. A full-sized layout must be made and spaced off; then the necessary lines and points are laid off on template paper.

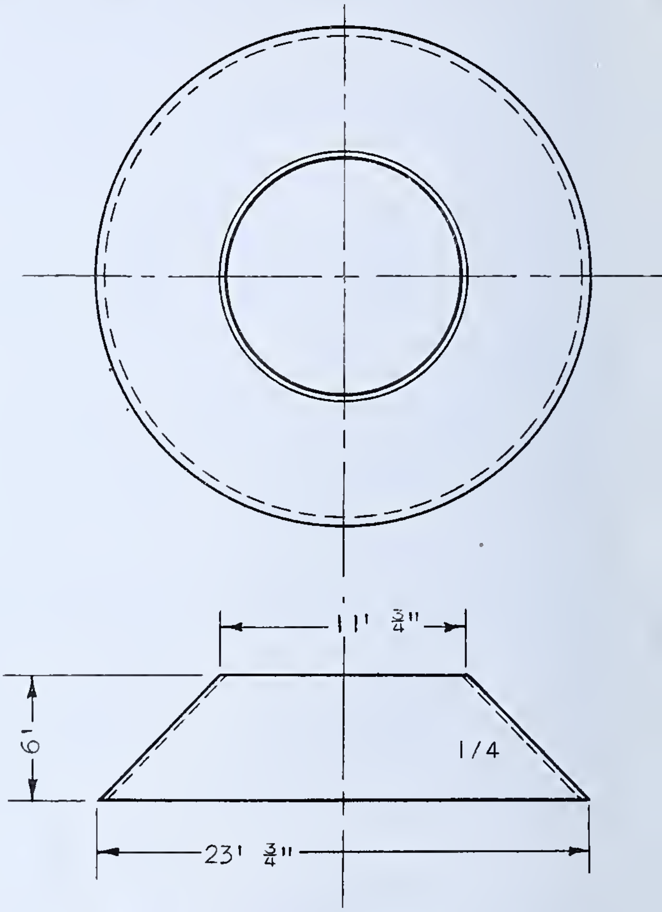


Fig. 302 — *Blueprint of Cone Frustum*

Tools and Equipment

1. Measuring wheel
2. Set of trammels (7′ stick)
3. Scriber
4. 12′ steel straightedge
5. 6″ steel straightedge
6. 1½-lb. ball-peen hammer
7. Center punch
8. Marking brush
9. 2 pairs 8″ dividers
10. Tin snips

Materials

Soapstone — Paint

Procedure

1. Make a layout to size of the cone frustum (Fig. 302) shown in the blueprint.

   The layout appears as in Fig. 303. The dimensions of the circles are based on neutral diameters.

2. Divide one-fourth of the circumference of the smaller diameter into eight equal spaces (Fig. 304).

   Lay the dividers aside for future use.

3. Divide one-fourth of the circumference of the larger diameter into eight equal spaces (Fig. 304).

   Lay the dividers aside for future use.

4. Scribe a horizontal line about 7′ long.
5. Erect a perpendicular at the center of the 7′ line as shown at *o-w* in Fig. 305.
6. Measure off a vertical distance (*o-w*) 6′ from the horizontal line. See Fig. 305, which shows the last three steps.
7. Number the intersections in Fig. 304, *0* to *8* and *a* to *i* as shown.
8. Set the trammels to distance *o-a* in Fig. 304.
9. Transfer this distance to Fig. 305, *o-a*.
10. Set the trammels to distance *o* (on the large diameter) to *b* (on the small diameter) in Fig. 304.
11. Transfer this distance to dotted line *o-n* (Fig. 305).
12. Obtain a piece of template paper the width of the roll and 12′ long.
13. Scribe a horizontal line *x-x* close to the edge of the template paper as shown in Fig. 306.
14. Scribe a short line *o* on horizontal line *x-x* in Fig. 306.
15. Set the trammels to distance *w-a* in Fig. 305.
16. Transfer this distance to *o-a* in Fig. 306.

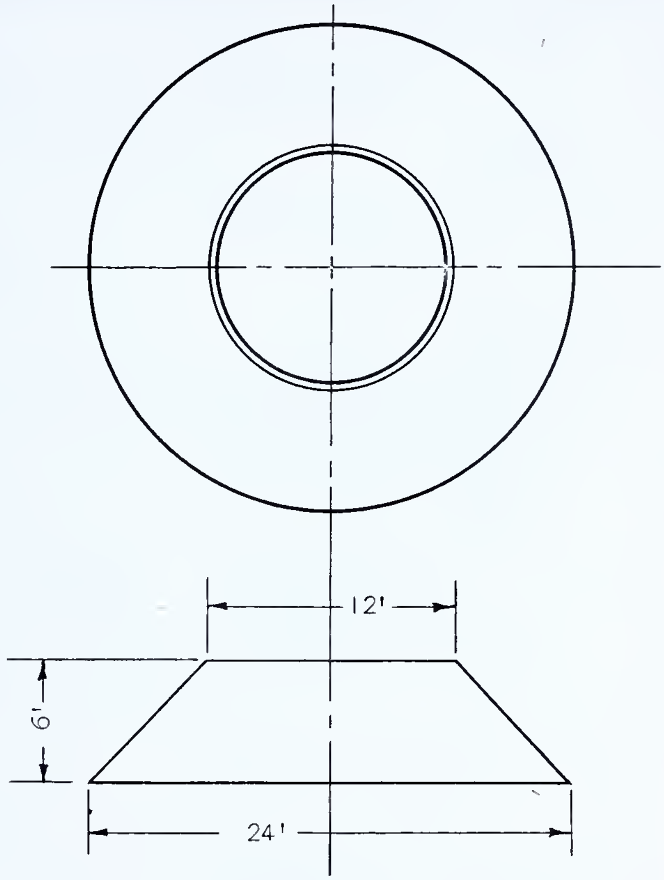


Fig. 303 — *Cone Frustum Layout*

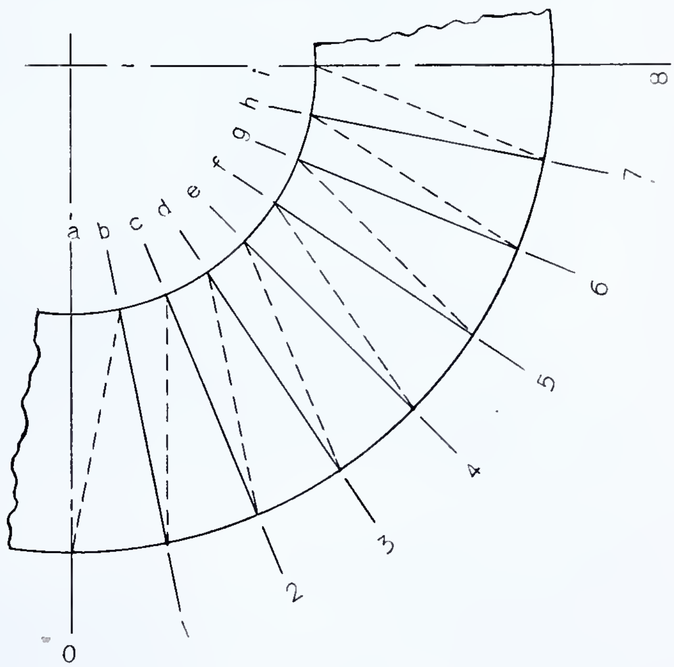


Fig. 304 — *Circumference Divided Into Eight Equal Spaces*

17. Set the dividers (used in Step 2) with one leg at intersection *a* and scribe a short arc *b*.

18. Set the trammels to distance *n-w* in Fig. 305.

19. Transfer this distance to Fig. 306.

Set one trammel point in intersection *o* and scribe an arc cutting the arc scribed in Step 17.

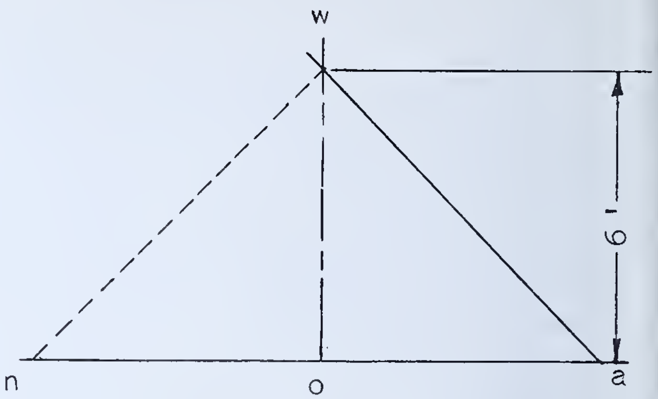


FIG. 305 — *Steps* 4, 5, *and* 6

20. Set the dividers (used in Step 3) with one leg at intersection *o* and scribe a short arc.

21. Set the trammels to distance *o-a* (Fig. 306).

22. Set one trammel point in intersection *b* and scribe a short arc cutting the arc scribed in Step 20.

23. Continue setting the tramels to distance *w-a* and *w-n* in Fig. 305 and use the divider settings given in Fig. 304.

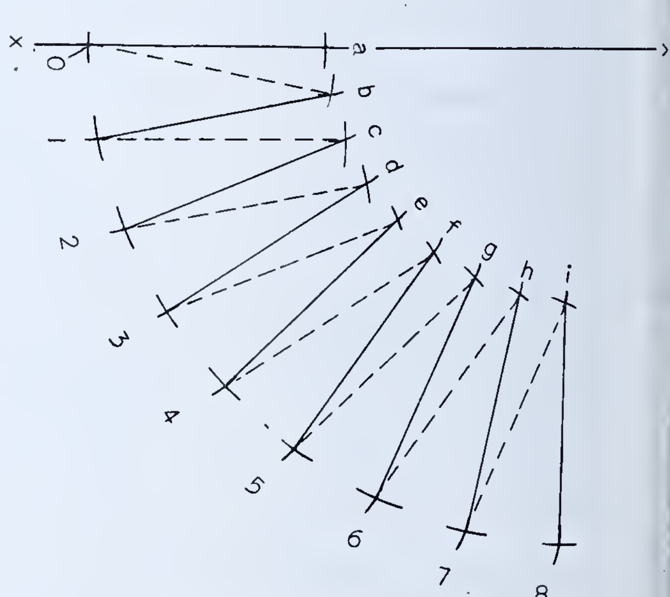


FIG. 306 — *Steps* 16 *to* 23

Use these settings to make successive intersections as shown in Fig. 306. The same steps are made as in Steps 17 to 22. When all the intersections have been scribed the work will appear as shown in Fig. 306.

24. Scribe curved lines (Fig. 307) to flow uniformly through the intersections scribed in Fig. 306.

CHECKING FOR ACCURACY

The template as now laid out should be equal to one fourth of the required cone frustum. When formed in the flange press, four of these shapes should make a full cone frustum of the size shown by the dimensions in the blueprint. To check the accuracy of the template it is necessary to proceed as follows:

PROCEDURE

1. Find the circumference of the neutral diameter of the large end of the cone frustum.

   Neutral diameter 24′ x 3.1416 = 288″ x 3.1416 = 904.7808″ = 75.3984′ = 75′ 4¾″.

2. Find one-fourth of the circumference.

   75′ 4¾″ divided by 4 equals 18′ 10-3/16″.

3. Find the circumference of the neutral diameter of the small end of the cone frustum.

   Neutral diameter 12′ x 3.1416 = 144″ x 3 1416 = 452.3904″ = 37.6992′ = 37′ 8⅜″.

4. Find one-fourth of the circumference.

   37′ 8⅜″ divided by 4 equals 9′ 5-3/32″.

5. Place the measuring wheel at point *o* (Fig. 307) and wheel the outside curve.

   The length should check 18′ 10-3/16″. If the length of the curve does not check with these figures, an error has been made which must be found before the work can proceed.

6. Place the measuring wheel at point *a* (Fig. 307) and wheel the inside curve.

   The length should check 9′ 5-3/32″. If the length of the curve does not check with these figures, an error has been made which must be found before the work can proceed.

When both lengths check correctly:

7. Cut the template on the border lines.
8. Mark on the template: 4 off.
9. Lay the template on the steel plate and mark with soapstone all around the edge.
10. Center-punch-mark the soapstone line to guide the burner in cutting the plate to size.
11. Mark the plate: ROLL SMALL END to 6′ RADIUS AND THE LARGE END to 12′ RADIUS.
12. Place the marked plates for the rolling operations.

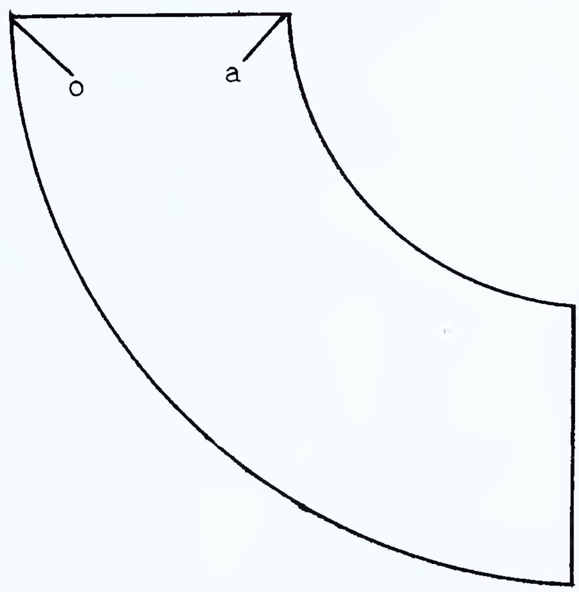


FIG. 307 — *Curved Lines Scribed Through Intersections Scribed in Fig.* 306

QUESTIONS

1. Why is only a one-fourth template necessary for this job?
2. Explain how the layout is accomplished by triangulation.
3. Why are the two pairs of dividers kept at the same setting throughout the layout operation?
4. How does the boilermaker make a check for the correct length of the template?
5. State the correct markings which are painted on the steel plates.

JOB SHEET NO. 8
TO LAY OUT A 90-DEGREE ELL

General Information

Heavy steel elbows are often used to connect straight pipe lines in certain units. The required bend is made up in sections from flat plate instead of being bent from a piece of straight pipe into an elbow shape; then the sections are welded together. After the welding is finished, the joints are ground smooth.

Since an elbow fabricated in this manner will be an exact fit in the location for which it is intended, it is considered to be a more economical method than that of attempting to bend a pipe by heating. In the fabricated job the walls of the elbow are of uniform thickness.

A bent pipe stretches thin on the outside of the bend and causes a weakening of the pipe wall. The shape and size of the elbow are shown in Fig. 308.

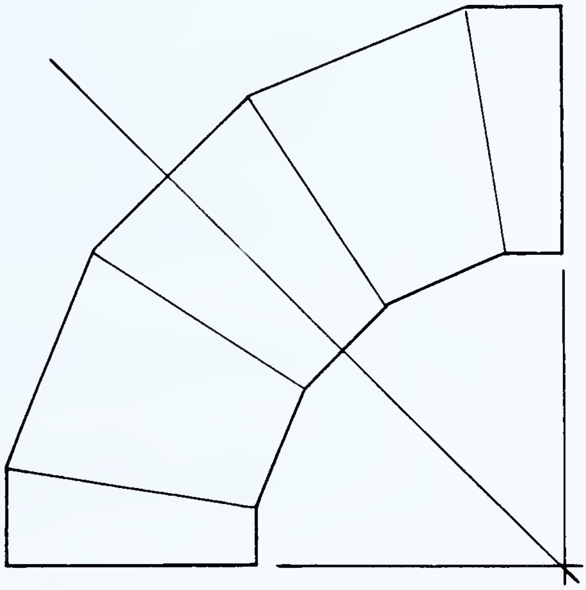


Fig. 308 — *As the Elbow Appears on the Blueprint*

Tools and Equipment

1. Dividers
2. Trammels
3. 7-ft. steel straightedge
4. Scriber
5. 24″ steel square
6. Small C clamps
7. Ball-peen hammer
8. Center punch
9. 6-ft. folding rule

Materials

Soapstone

Paint

Marking brush

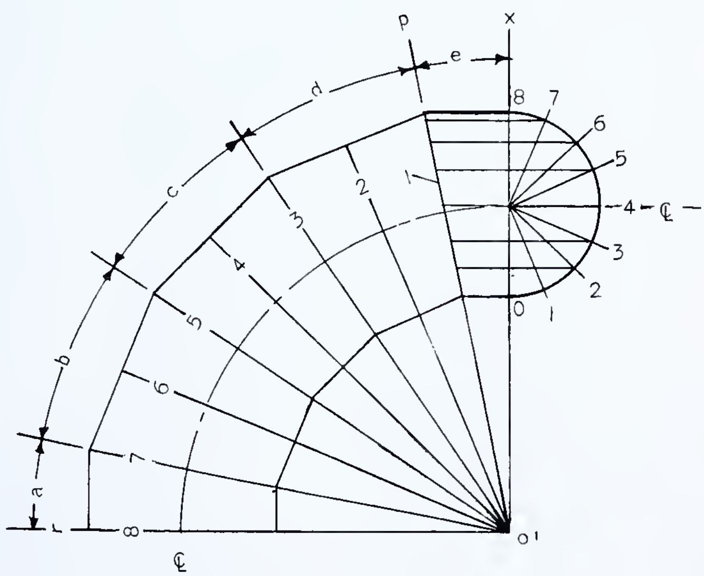


Fig. 309 — *Elbow Layout*

PROCEDURE

1. Make a layout of the elbow as shown in Fig. 309. Use the neutral diameter of the elbow (24⅜″).

   a. Divide the center line of the elbow into 8 equal spaces, and number the lines (which define the spaces) from 1 to 8.

   b. Scribe radial lines from center o^1 to cut the outer line of the elbow layout.

   Note that three triangular-shaped figures (Fig. 309) indicated by *b*, *c* and *d* are inclosed by lines *5-7*, *3-5*, and *1-3*. See Fig. 310.

   The two end trangular-shaped sections *a* and *e* are half the size of the figures mentioned above. See Fig. 311, *A* and *B*. The third side of each figure is bounded by a line scribed at right angles to lines *2*, *4*, and *6*. More will be said about these triangular-shaped figures later on in this job sheet

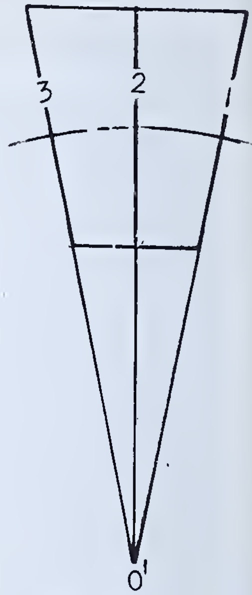


FIG. 310 — *Sections* b, c, *and* d

2. Scribe a semicircle as shown in Fig. 309. Place one leg of the dividers on the point where center line *o′-x* crosses the center line of the layout.

3. Divide this half-circumference into eight equal parts.

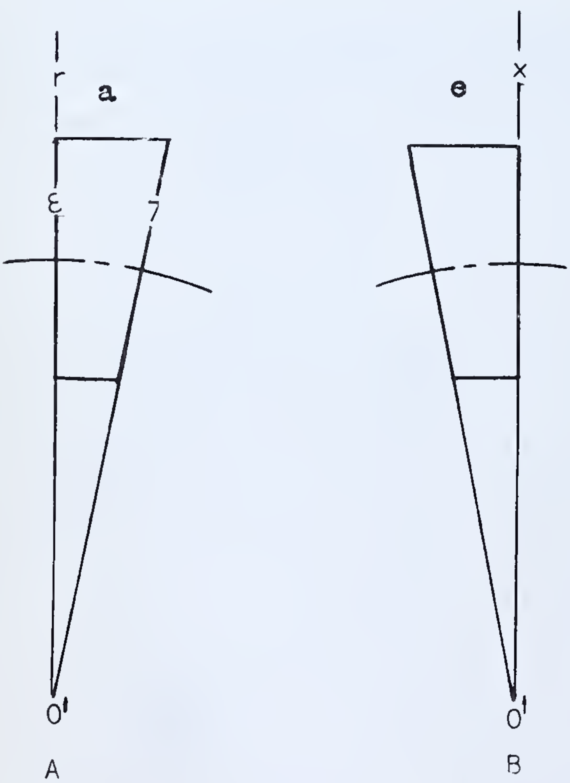


FIG. 311 — *Sections* a *and* e

4. Project lines through the intersections of the radii with the semicircle so that they are at right angles to the center line *o′-x*.

5. Continue these lines to line *o′-p* as shown.

6. Find the circumference of the 24⅜″ neutral diameter of the elbow.

   24⅜″ x 3.1416 equals 76.57, or approximately 76½″.

7. Obtain a piece of template paper 84″ long and 26″ to 28″ wide. Fig. 312.

8. Scribe a line (*s-t*) in the center of the template paper the full length of the paper.

9. Scribe two lines *m-n* and *k-l* at right angles with the center line *s-t* and 76½″ apart (the length of the circumference of the neutral diameter of the elbow).

0. Scribe three lines *c-d, e-f,* and *g-h* at right angles with the center line *s-t* to divide the distance between lines *m-n* and *k-l* into four equal spaces.

1. Divide each one of the four spaces measured off in Step 10 into four equal spaces.

   These four equal spaces compare with the four spaces stepped off on the semicircle scribed in Fig. 309.

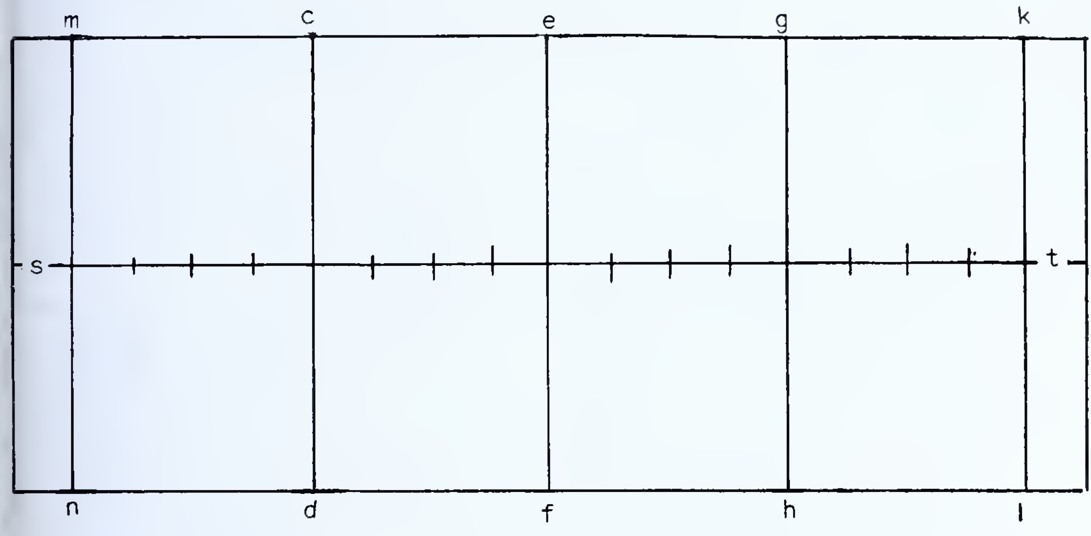


FIG. 312 — *Beginning of a Template Layout*

12. Scribe short arcs on each of the lines scribed at right angles with center line *s-t,* Fig. 313.

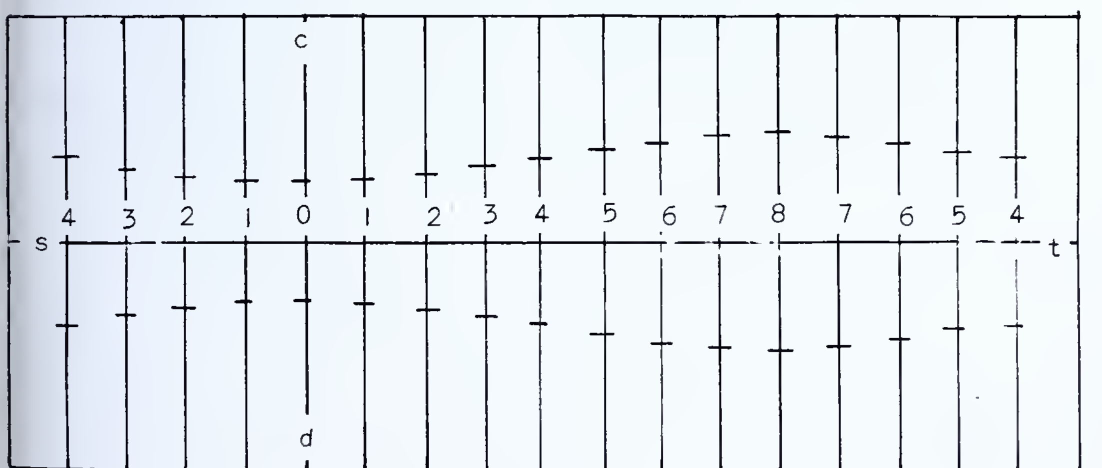


FIG. 313 — *Template Ready for Scribing Curved Lines*

a. Number the intersections of the vertical lines with center line *s-t,* beginning with vertical line *c-d.* Number this intersection *o.*

b. Continue numbering the intersections to the right and to the left as shown in Fig. 313.

c. Set the dividers to the correct distance and step off the intersections shown in Fig. 313.

Figure 314 is a duplicate of the right-hand side of Fig. 309. The semi-circle has been set off to the right. The first section of the elbow layout in Fig. 309 has the corresponding projected lines numbered for clarity. The lengths of the projected lines *o* to *8* are to be transferred to the layout in Fig. 313. The first divider setting is the distance from line *o-x* to *o* on the line *o-p*.

d. Transfer this distance to line *c-d* in Fig. 313. With one divider point set on point *o*, scribe short arcs.

e. Set the dividers to distance from *1* to line *o-x* and transfer this distance to lines *1* in Fig. 313.

f. Continue transferring the rest of the distances as shown in Fig. 313.

Note that the lines which are numbered the same are stepped off the same distances. All of the distances are stepped off equally first above and then below the center line *s-t*. The main divisions on Figs. 312 and 313 represent one fourth of the circumference of the elbow measured on the neutral diameter. When the lines *m-n* and *k-l* are brought together after the job is rolled, they represent the seam which is to be welded in the circle.

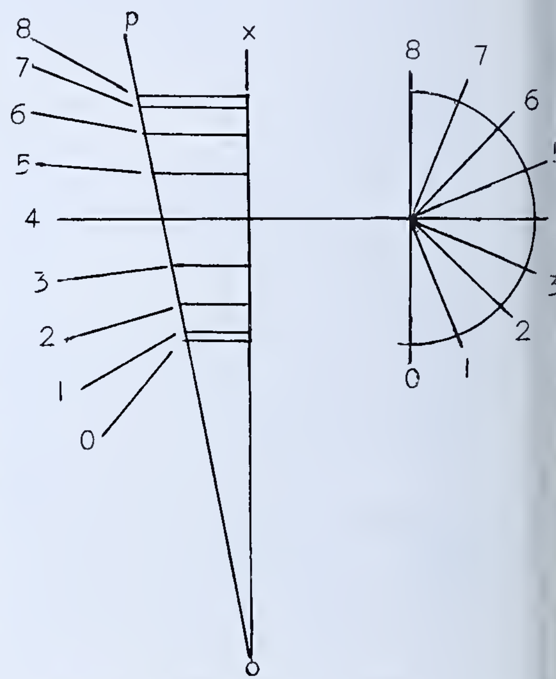


Fig. 314 — *Section* e *in Fig.* 309

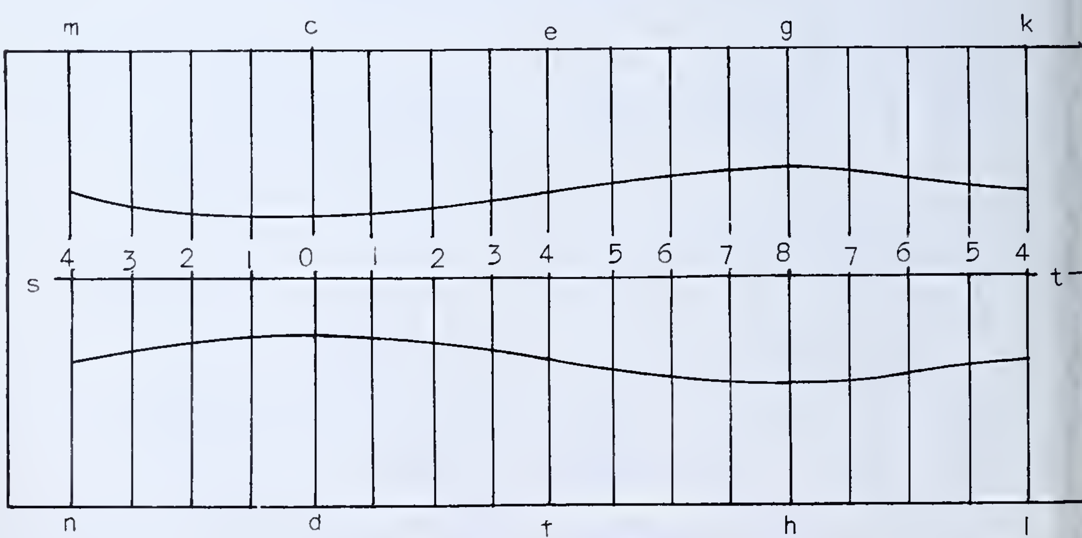


Fig. 315 — *Curved Lines Scribed through Intersections*

13. Scribe lines through the intersections in Fig. 313 so that the layout will appear as shown in Fig. 315.

14. Cut the template paper on the curved lines and on the end lines *m-n* and *k-l*.

    The template now appears as shown in Fig. 316.

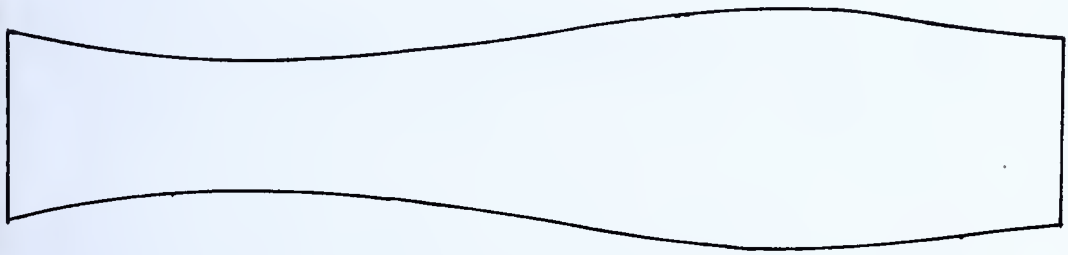


Fig. 316 — *Finished Template*

Using the Template

Note that Fig. 309 is lettered in divisions *a, b, c, d,* and *e*. The template shown in Fig. 316 is used to lay off divisions *b, c,* and *d* as follows:

a. Lay the template on the steel plate and mark all around it with soapstone.

b. Center-punch the scribed line to guide the burner when cutting the steel plate.

c. Repeat steps *a* and *b* until the required number of plates are laid out.

Three pieces are enough for one elbow. There may be several elbows.

To mark around the template to lay out divisions *a* and *e* proceed as follows:

(1) Lay the template on the steel plate with the center line *s-t* even with a straight edge on the plate.

(2) Mark all around the curved line on the template and across the ends as shown in Fig. 317.

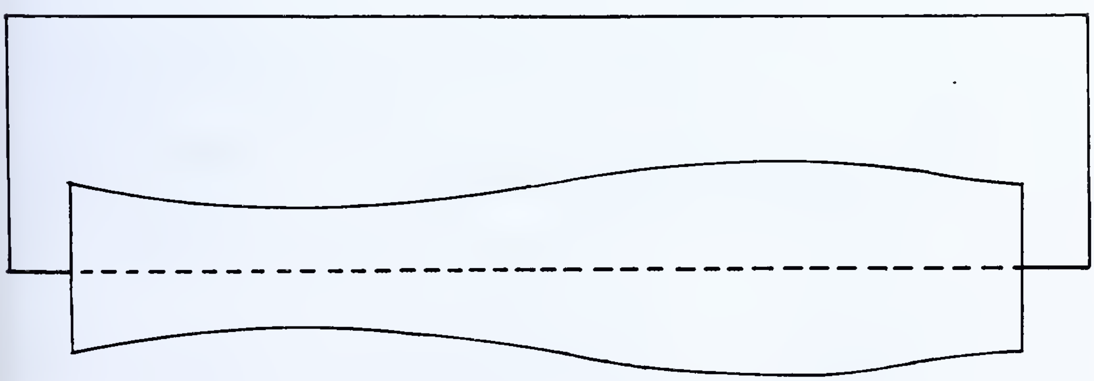


Fig. 317 — *Template Layout for End Sections*

Mismatched Joints

It will be noted that when the elbow sections are rolled and fitted together the welded seams will not match because the intersection *o* on line *c-d* in Fig. 313 was placed at one end of the template instead of in the center. Mismatching the seams makes possible a more uniform fit because the welded joints are not all in a straight line.

The student is urged to practice making this elbow template by cutting out pieces of tin, bending the pieces to shape, and fitting them together as in actual shop practice. The work can be done to scale (1/16″ to the inch), and actual experience can be gained in this manner.

Marking the Cutout Plates

The plates are marked with paint: ROLL OUT TO 24″ I.D. Mark the plates on the same side as that on which the layout markings were made. The plates are then taken to the horizontal rolls to be rolled to shape.

QUESTIONS

1. State the reason for dividing the length of the template into four equal divisions.

2. What is the neutral diameter of a cylinder that has an inside diameter of 14″ and a plate thickness of 3/8″?

3. Where are the dividers used when laying out a template such as was described in this job sheet?

4. State the use of the trammels on this job.

5. Explain the reason for laying out a semi-circle and dividing it into a number of equal spaces.

6. The spaces into which the semi-circle for this job was divided number eight. Is this number of spaces the same for all layouts of this kind?

7. What is the advantage of a greater number of spaces in the semi-circle.

8. What would be the result if the spaces on the semi-circle in the layout were not marked equally?

JOB SHEET NO. 9
TO LAY OUT A STACK UMBRELLA

General Information

A stack umbrella fits over the top of the smoke stack and covers the open space between the round inner stack and the oval-shaped outer stack. The umbrella and the top of the stack are shown in section in Fig. 318. The umbrella is made

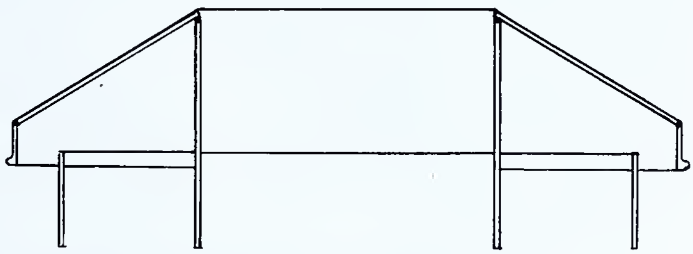


Fig. 318 — *Stack Umbrella*

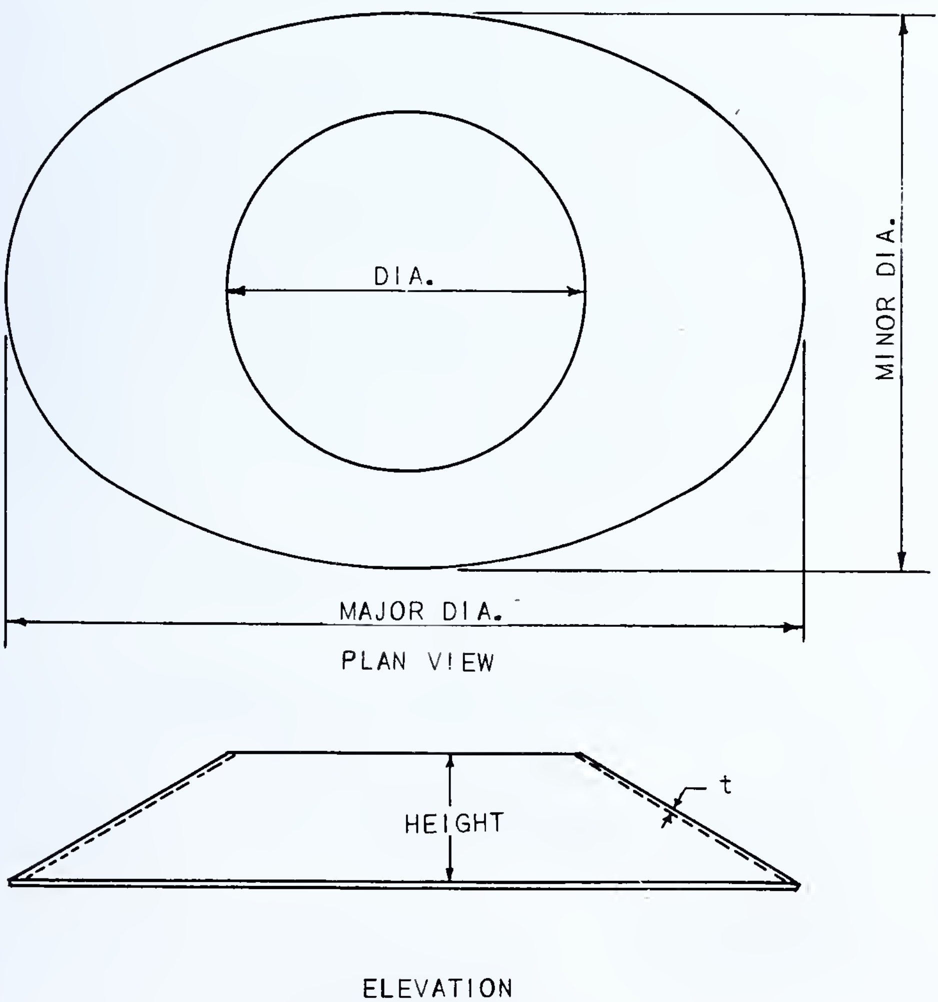


Fig. 319 — *Top and Front View as Shown on the Blueprint*

in four pieces which are welded together to form a continuous slanting apron all around the stack. The plan and front views of the umbrella are shown in Fig. 319. The blueprint shows the umbrella in greater detail but for the sake of clarity only the important dimensions required for the purposes of this job sheet are given in Fig. 319. The thickness of the steel plate is shown at *t* and this thickness is usually 1/4″

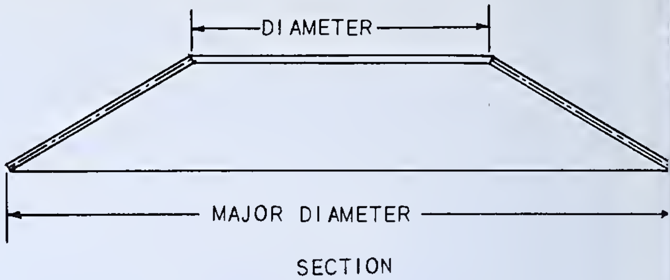


Fig. 320 — *Neutral Diameters*

Since these umbrellas are several feet in diameter it is not convenient to lay out a template by the parallel line method which was used in Job Sheet No. 4. The method of triangulation used in Job Sheet No. 7 will be used for this job.

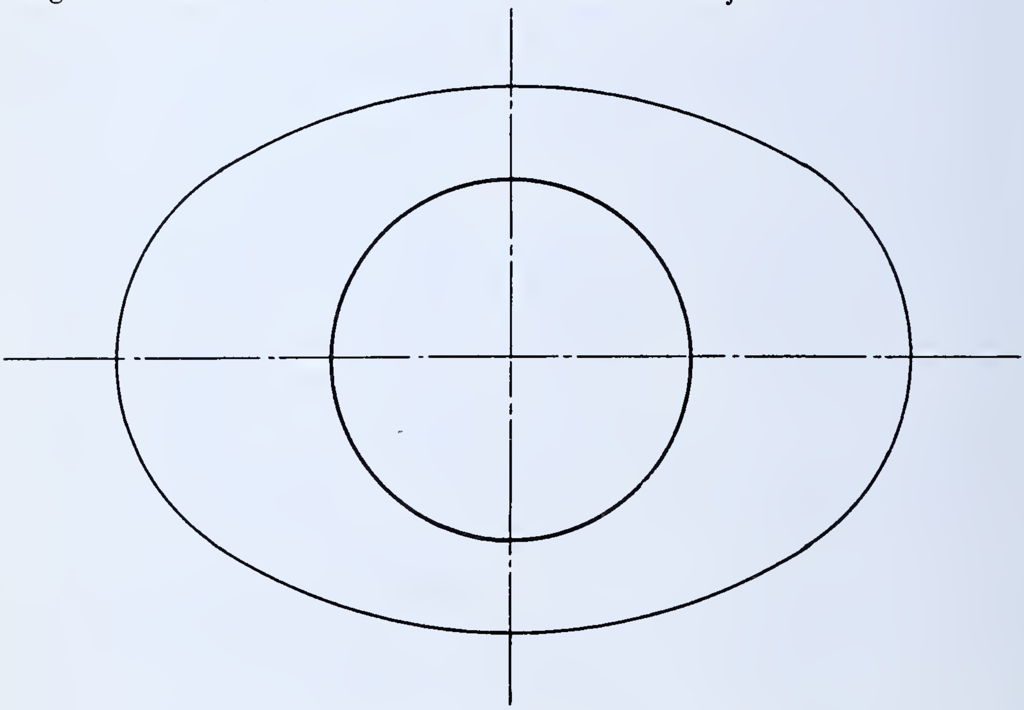


Fig. 321 — *Layout of Umbrella*

Tools and Equipment

1. Two pairs of extension dividers
2. Trammels and stick
3. Ball-peen hammer
4. Center punch
5. 6′ Folding rule
6. Scriber
7. Straightedge
8. Tin snips
9. Paint brush

Materials

Soapstone Paint

'ROCEDURE

1. Make a full-size layout of the job as shown in Fig. 321.

Obtain the correct dimensions from the blueprints. Use the neutral diameters to lay out the curves. Obtain the neutral diameters from a layout as shown in Fig. 320.

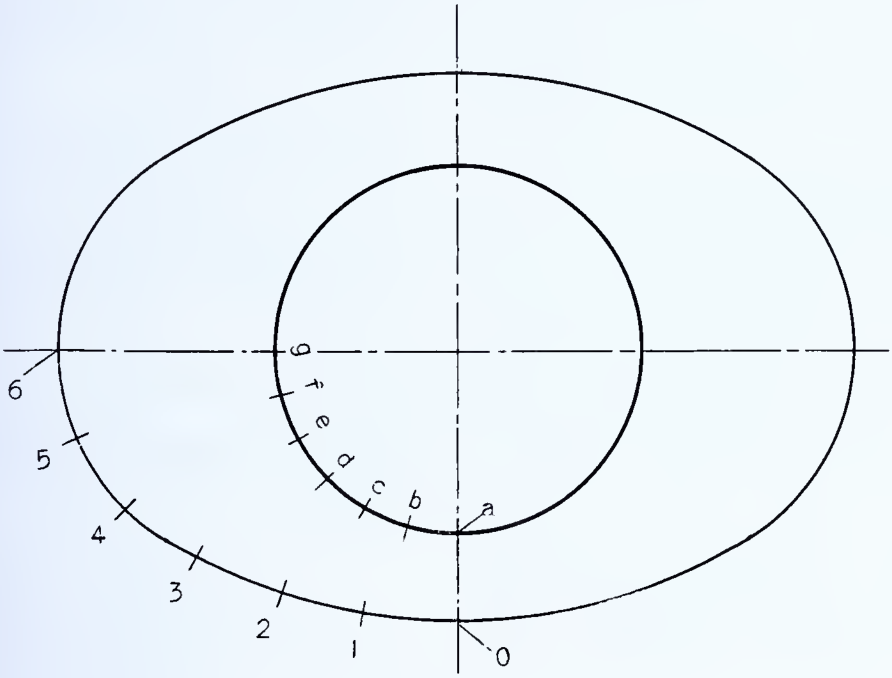


FIG. 322 — *Divisions on Curves*

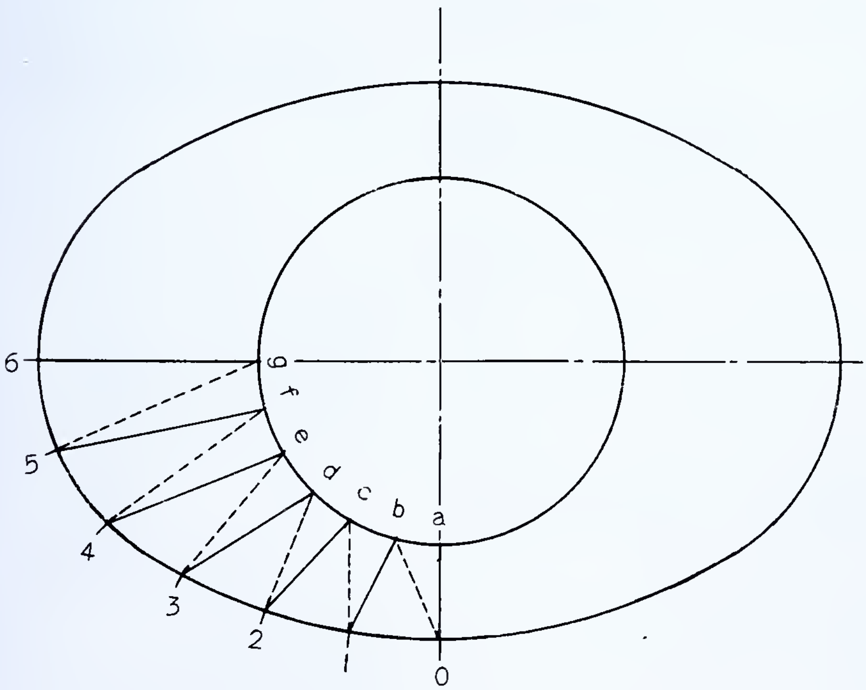


FIG. 323 — *Division Points Connected*

2. Divide the circle into twenty-four parts. See Fig. 322. Leave the dividers set fo future use.

   In that only one-fourth of the layout will be used for the template it is necessar to divide only one-fourth of the circle into six equal parts.

   For the sake of clarity the entire layout is shown but only one-fourth is used.

3. Divide the corresponding quarter of the oval into six equal parts.
   Leave the dividers set for future use.

4. Number the divisions on the circle from *a* to *g* as shown in Fig. 322.

5. Number the divisions on the oval from *0* to *6* as shown in Fig. 322.

6. Connect the division points on the *a-g* circle to the division points on the *0-6* ova with full lines as shown in Fig. 323.

7. Connect the division points on the *a-g* circle to the division points on the *0-6* ova with dotted lines as shown in Fig. 323.

   The same method of laying out is used here that is used in laying out a con frustum but the template will be shaped differently.

8. Scribe a line as shown at *x-x* in Fig. 324, long enough to pick up the distances shown at *g-5* and *g-6* in Fig. 323.

   If this line is not long enough at first trial, it can be extended as required.

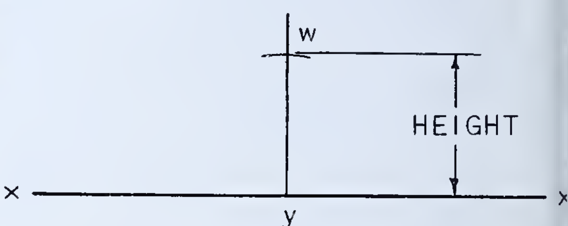


FIG. 324 — *Steps 8 to 10, Inclusive*

9. Erect a perpendicular at *y* on line *x-x* high enough to allow the height of the umbrella (Fig. 319) to be scribed across it at *w*.

10. Scribe a short line at *w* across the perpendicular.

11. Set the trammels to distance *o-a* in Fig. 323 (full line).

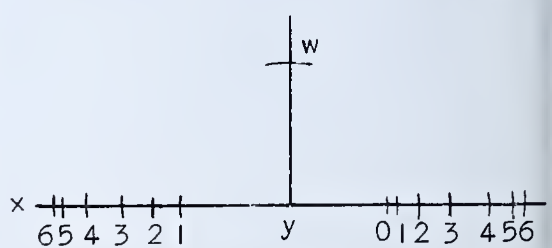


FIG. 325 — *Steps 12 to 15, Inclusive*

12. Set one trammel point at *y* in Fig. 325 and scribe a short arc on line *x-x* to the right of the perpendicular at *o* as shown in Fig. 325.

13. Set the trammels to distance *1-b* in Fig. 323.

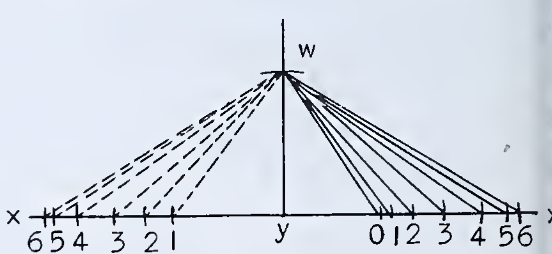


FIG. 326 — *Step 19*

14. Set one trammel point at *y* in Fig.

325 and scribe a short arc on line *x-x* at *1* as shown in Fig. 325.

15. Continue setting the trammels and transferring the distances to the layout as shown in Fig. 325 until all of the intersecting arcs have been scribed.

16. Set the trammels to distance *o-b* in Fig. 323 (dotted line).

17. Set one trammel point at *y* in Fig. 325 and scribe a short arc on line *x-x* to the left of the perpendicular at *1* as shown.

18. Continue setting the trammels and transferring the distances to the layout as shown in Fig. 325, until all of the intersecting arcs have been scribed.

19. Connect the intersecting points on line *x-x* with lines as shown in Fig. 326.

FIG. 327 — *Laying Out the Template*

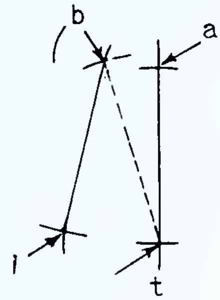


FIG. 328 — *Step* 26

Scribe dotted lines to the left of the perpendicular; scribe full lines to the right of the perpendicular.

20. Obtain a piece of template paper approximately two-thirds the size of the layout shown in Fig. 321.

21. Scribe a perpendicular line at the right side of the template paper as shown at *t-t* in Fig. 327.

22. Set the trammels to distance *w-y*, full line, Fig. 326.

23. Set one trammel point at *o* in Fig. 327 and scribe a short arc at *a*.

24. Use the dividers with the setting obtained in Step 2; set one divider point in intersection *a* on a line *t-t* and scribe a short arc at the left as shown in Fig. 327.

25. Set the trammels to distance *1-w* (dotted line) in Fig. 326.

26. Set one trammel point in intersection *o* on line *t-t* and scribe a short arc cutting the arc scribed in Step 24 as

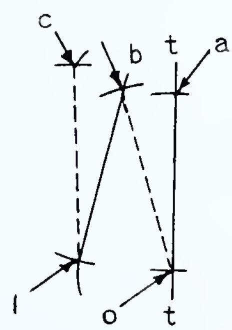


FIG. 329 — *Step* 32

shown in Fig. 328. Mark the intersection *b*.

27. Use the dividers with the setting obtained in Step 3 and set one divider point in intersection *o* on line *t-t* and scribe a short arc at the left as shown in Fig. 328.

28. Set the trammels to distance *o-w* (full line) in Fig. 326.

29. Set one trammel point in intersection *b* in Fig. 328 and scribe a short arc cutting the arc scribed in Step 27 as shown in Fig. 328. Mark the intersection *1*.

30. Use the dividers with the setting obtained in Step 2; set one divider point in intersection *b* in Fig. 328 and scribe a short arc at the left as shown in Fig. 328.

31. Set the trammels to distance *2-w* (dotted line) in Fig. 326.

32. Set one trammel point in intersection *1* in Fig. 328 and scribe a short arc cutting the arc scribed in Step 30 as shown in Fig. 329, at *c*.

33. Use the dividers with the setting obtained in Step 3 and set one divider point in intersection *1* in Fig. 329 and scribe a short arc at the left as shown in Fig. 329.

34. Set the trammels to distance *3-w* (full line) in Fig. 326.

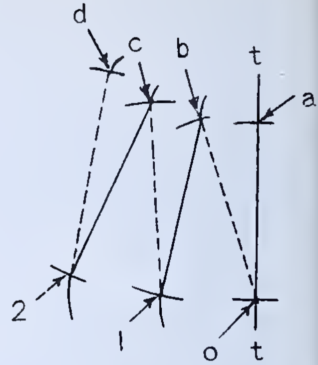


FIG. 330 — *Step 35*

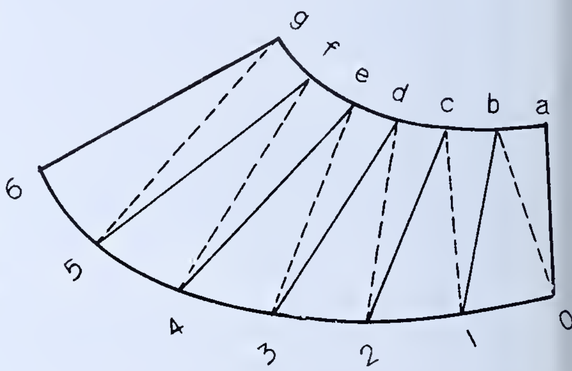


FIG. 331 — *Completed Layout*

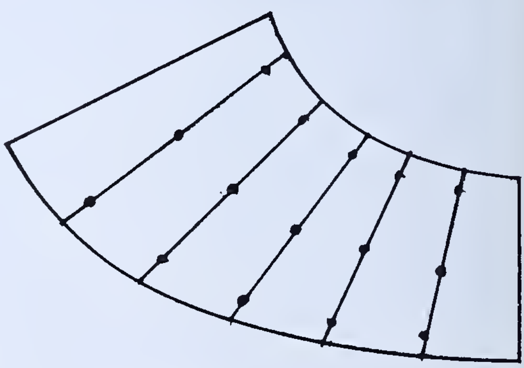


FIG. 332 — *Template Cut Out*

35. Set one trammel point in intersection *c* in Fig. 329 and scribe a short arc cutting the arc scribed in Step 33 as shown in Fig. 330.

36. Continue with the dividers and the trammels and use them in the manner heretofore described until the intersections have all been made, including point *g* on the circle circumference and the point *6* on the oval circumference, as shown in Fig. 331.

37. Connect the points *0, 1, 2, 3, 4, 5, 6* with a curved line.

Use a thin piece of template wood, stand it on edge to pass through the points, and scribe a line with soapstone, or a scriber.

38. Connect the points *a, b, c, d, e, f, g* in the same manner.

39. Cut the template on the curved lines and on line *a-o* and *g-6*.

40. Mark the template:

2 OFF THIS SIDE UP AND 2 OFF THE OTHER SIDE UP

41. Center-punch-mark each full line in three places as shown in Fig. 332.
The steel plate is bent on these lines to form a conical shape.

NOTE: To check the accuracy of the template, wheel the layout on the oval and wheel the template in a similar manner. They should check the same. If not, there has been an error in the layout work.

JOB SHEET NO. 10
TO LAY OUT AN UPTAKE

General Information

The two views of completed uptakes (Figs. 571 and 572) show the shaped plates neatly assembled and ready to be transported to the wet basin where they will be placed aboard ship.

A close study of the uptakes will reveal that the plates which form the front, back, and sides of each uptake are shaped to a certain pattern before they are assembled. Study Figs. 561, 565, 567, and 568 to learn how the several plates are erected. Each plate must be laid out, cut, and formed to a certain shape and in addition to this the uptakes are made in pairs, one right-hand and one left-hand.

If it were possible to lay out, cut, and form the plates without blurring or smearing the layout lines, the finished job would have the appearance of the work shown in Fig. 333. The lines shown in Fig. 333 are actually laid out on template paper and are then transferred to the steel plates (before they are bent) with center-punch marks and soapstone pencil. See Fig. 348.

The uptakes *A* and *B* shown in Fig. 333 are right and left or starboard and port. Uptake *B* has been removed in Fig. 334 to show the layout lines which are hidden in Fig. 333. It must be

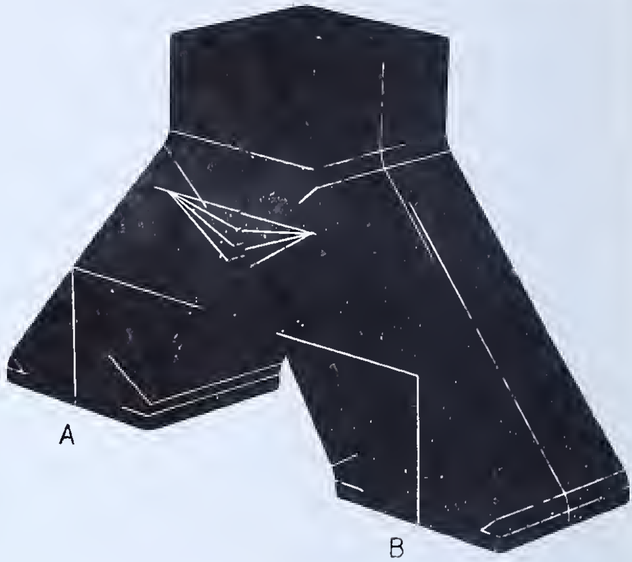


Fig. 333 — *Layout Lines*

Fig. 334 — *Uptake* A *Shown in Fig.* 333, *without Uptake* B

kept in mind that uptake *A* is exactly the reverse of uptake *B*. If the bend in *A* at a certain point leads to the left, the corresponding bend in *B* leads to the right.

The Layout Dimensions

The blueprint gives the dimensions for the completed job. The layout man must compute the neutral radii where necessary. The blueprint does not give information on methods to be employed for making the layout.

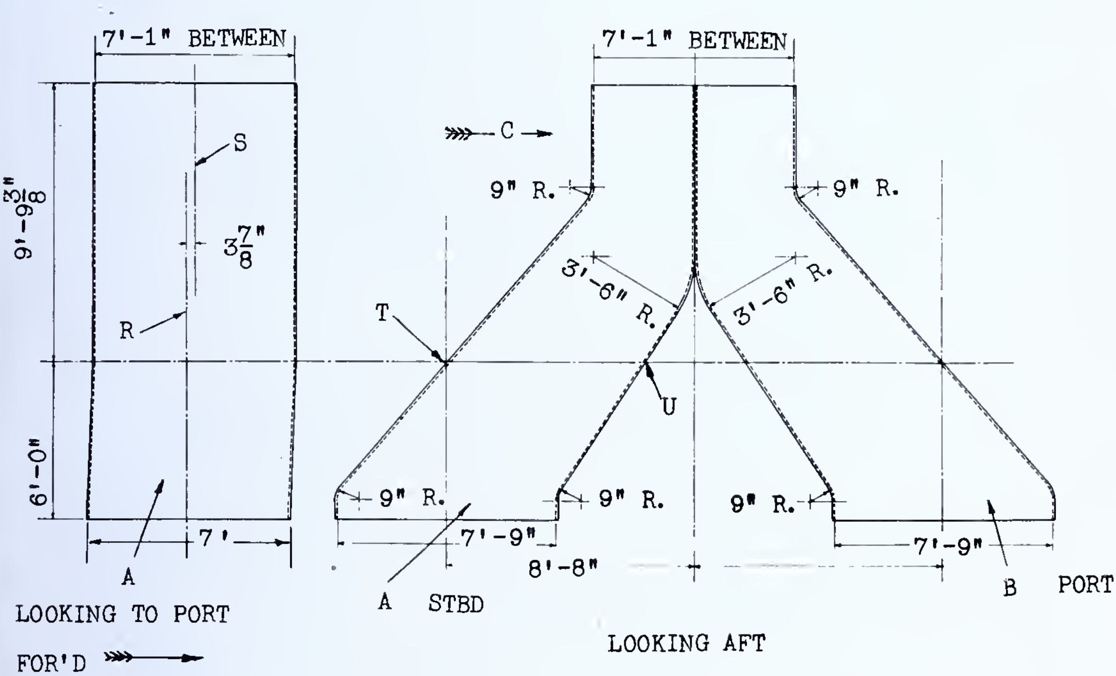


Fig. 335 — *As the Blueprint Shows the Uptake*
(*Some dimensions are omitted. See Drawing* 241-880-1 *for complete details*)

Reference: Drawings 241-880-1, right and left are in the back of this manual. Use them as a reference for the study of this job sheet.

The work of making a layout and the necessary templates for an uptake may be summarized as follows:

Tools and Equipment

1. 6′ Folding rule
2. 6′ Straightedge
3. 12′ Straightedge
4. 12″ Dividers
5. Set of trammels and beam
6. Scriber
7. Measuring wheel
8. Four C clamps
9. Marking brush
10. Tin snips
11. Steel square
12. Ball-peen hammer

Materials

Chalk White paint

PROCEDURE

1. Make a full-size layout of the forward, starboard side of the uptake as shown in Fig. 336.

   The four members of the uptake which are shaped like this piece can be made from the same template. When making this layout, work to the dimensions given in Fig. 335. The corners where the plates come together do not lap but are made to meet as shown in Fig. 337.

   After the members of the uptake are assembled and clamped in place, the corners *W* are welded along the length of the uptake from top to bottom.

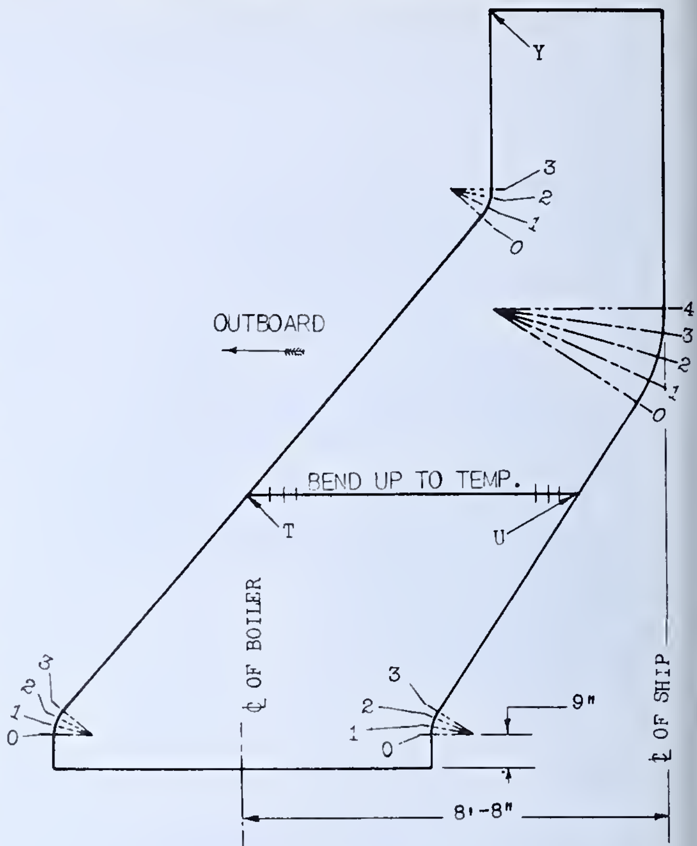


FIG. 336 — *Full-Size Layout*

2. Make two templates for the rectangular box (expansion piece) 83 shown in Drawing 241-880-1, Right. See Fig. 338.

   The templates are shown in Figs. 339 and 340. Lay them aside for future use when marking the steel plates.

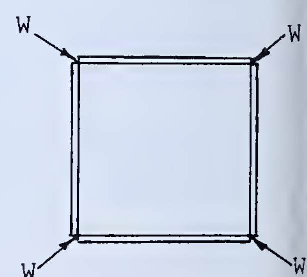


FIG. 337

3. Make a template for the forward and after plate shown in Fig. 341.

   This template must be laid out to produce the correct length on the flat plate so that after the plate is bent it will be long enough to fit against the inboard and outboard plates shown in Figs. 343 and 347.

The measurements for the "Bend up to Temp." line in Figs. 336 and 341 are found on the detail drawing. Figure 342 shows the offset in the view "Looking to Port", Fig. 335. Figure 344 is the layout for the left-end view shown in Fig. 335.

In that the slanting distance is greater than the vertical distance, an allowance for this must be made when laying out the flat plate.

TO MAKE TEMPLATE FOR FIG. 341

PROCEDURE

a. Obtain a piece of template paper long enough for the layout.

b. Scribe a base line. See Fig. 341.

c. Erect a perpendicular ℄ of boiler and parallel to it scribe the ℄ of the ship. Lay off, parallel with the base line, a line 9″ from the base line. See Fig. 341.

d. Step off and scribe width of uptake at bottom.

e. Measure with the wheel and obtain the slant length of the line in Fig. 342.

f. Wheel this length vertically on the template and scribe a line as shown in Fig. 341 "Bend up to Temp."

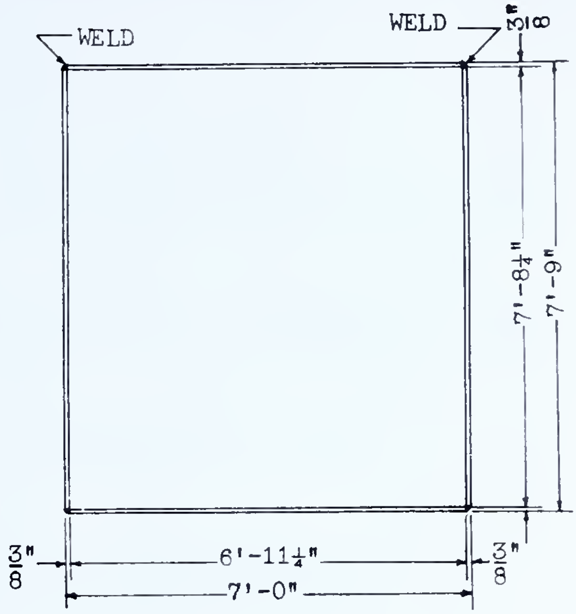


Fig. 338 — *Expansion Piece*

g. Measure vertically from "Bend up to Temp." line 9′-9⅜″ and scribe the top limit of the uptake as shown in Fig. 341.

h. Refer to Fig. 335. Lay off and scribe all radii as indicated on the blueprint.

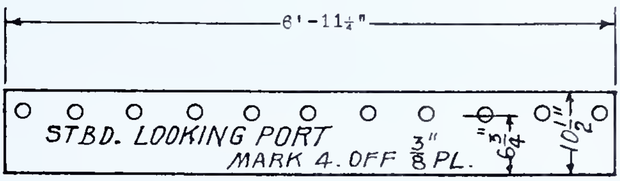


Fig. 339 — *Template for Expansion Piece*

i. Lay off and scribe a point *Y* on the top line of the uptake, 3′-6″ from the ℄ of the ship.

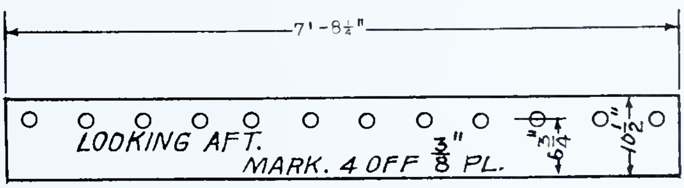


Fig. 340 — *Template for Expansion Piece*

j. Connect the intersection *T* with the 9″ radius *3* in Fig. 336, bottom left.

k. Connect the intersection *T* with the 9″ radius *0* in Fig. 336, upper left.

l. Connect the intersection *Y* with the 9″ radius *3* in Fig. 336, upper left.

m. Measure on the layout (Fig. 355) distance *T-U* and transfer the measurement to Fig. 336, *T-U*.

n. Connect the intersection *U* with the 9″ radius *3* in Fig. 336, lower right.

o. Connect the intersection *U* with the 3′-6″ radius *0* in Fig. 336, upper right.

p. Step off spaces on all radii as shown in Fig. 336, and scribe radius lines as shown.

4. Make a template for outboard-starboard plate. See Fig. 343.

This plate must fit along the contour of the starboard uptake shown in Fig. 335. The observer is looking in the direction arrow C is pointing when he sees Fig. 343.

The center line *R* in Fig. 343 corresponds to the center line *R* in Fig. 335. Center line *S* is 3⅞″ offset from center line *R*. All measurements are taken from these center lines when laying out the plate.

Refer to Fig. 333. The white lines correspond to the black lines in Fig. 336. To obtain the length of the outboard starboard plate, the measurements must be taken from the layout in Fig. 336.

To Make a Template for Fig. 343

Procedure

a. Obtain a piece of template paper long enough for the layout.

b. Scribe a base line. See Fig. 343.

c. Erect a perpendicular *R* as shown.

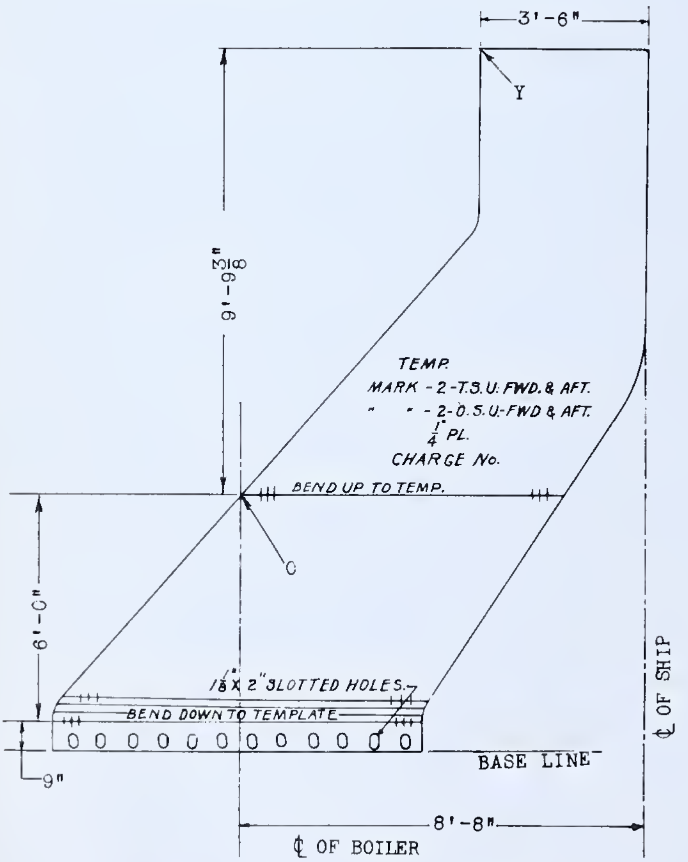


Fig. 341 — *Forward and Aft Plate*

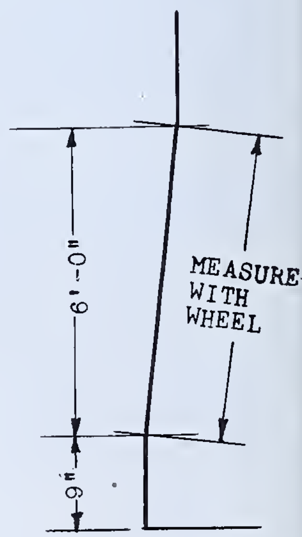


Fig. 342 — *Offset in Plate*

d. Lay off a line *S* parallel to *R* and 3⅞″ from it.

e. Step off 3′6″ each side of the center line *R* and scribe points on the base line.

f. With the steel square and scriber, scribe vertical lines 9″ long.

Refer to Fig. 333. The white lines which are scribed across the surface of the plate meet the radial lines. The horizontal lines shown at the bottom of Fig. 343 correspond to the horizontal lines shown in Fig. 333. These lines must now be located on the template in Fig. 343.

g. Wheel the layout from radial line *o* to radial line *3* in Fig. 336 at the lower left.

h. Transfer this distance to the template in Fig. 343, *0* to *3*.

i. Divide this distance into equal spaces as shown.

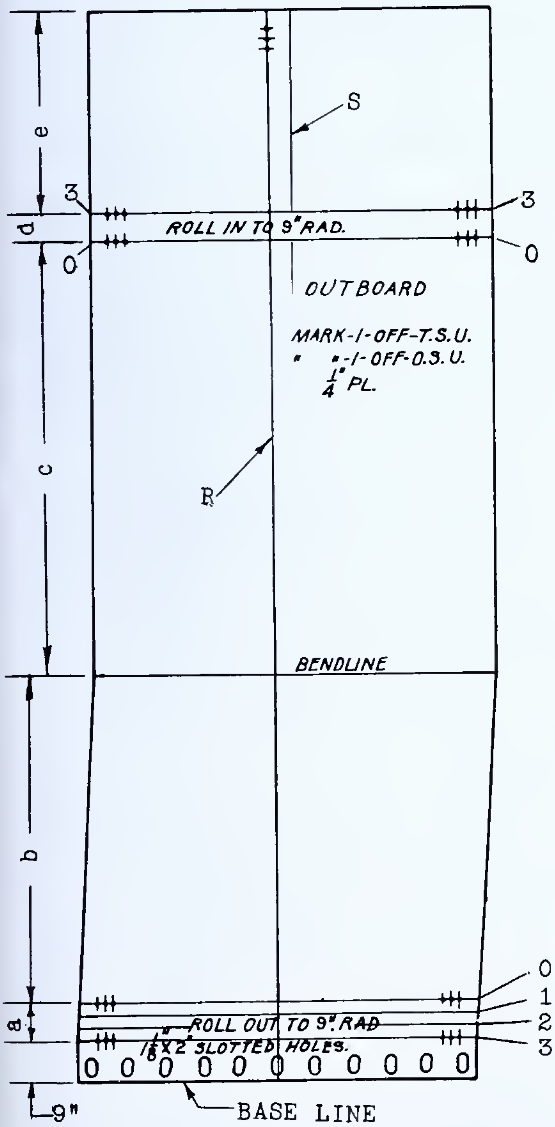


Fig. 343 — *Outboard Starboard Plate*

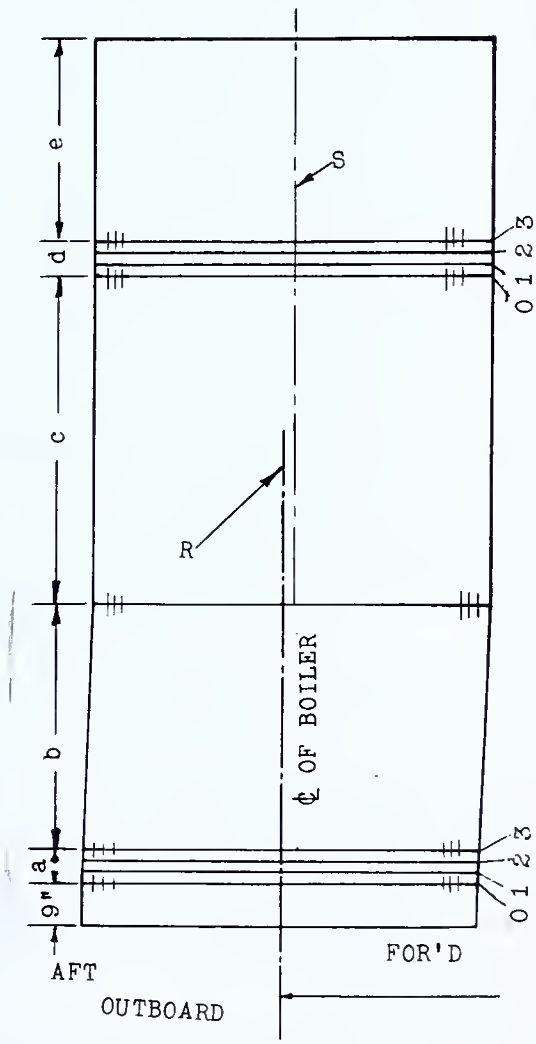


Fig. 344 — *Outboard Starboard Layout*

j. Set the trammels on the horizontal line *O* in Fig. 344 and obtain the distance from the center line to the after end of the line.

k. Transfer this distance to line *O* in Fig. 343 to correspond.

l. Repeat step *j* from the center line to the forward side.

m. Transfer this distance to line *O* in Fig. 343 to correspond.

n. Continue in the same manner and step off corresponding distances on the other lines.

o. Step off the bend-line lengths aft and forward from the center line *R* in layout, Fig. 344.

p. Transfer these lengths to the template in Fig. 343.

q. Step off the top aft and forward lengths from the center line *S* in layout, Fig. 344.

r. Transfer these lengths to the template in Fig. 343.

s. Measure for and locate all horizontal lines shown in Figs. 343 and 344.

The distances from the base line to each horizontal line is found as follows:

(1) Line *0* is 9″ from the base line.

(2) The location of line *1* is found by wheeling the distance from line *0* to line *1* on the curve. See Fig. 345.

(3) The location of lines *2* and *3* are found by wheeling on the curve as in Step 2.

(4) The location of the bend line is found by measuring from radial line *3* to intersection *T* in Fig. 336. Transfer this distance (*b*) to Fig. 343.

(5) The location of line *0* (upper end) in Fig. 343 is found by measuring from intersection *T* to *0* (upper end) in Fig. 336.

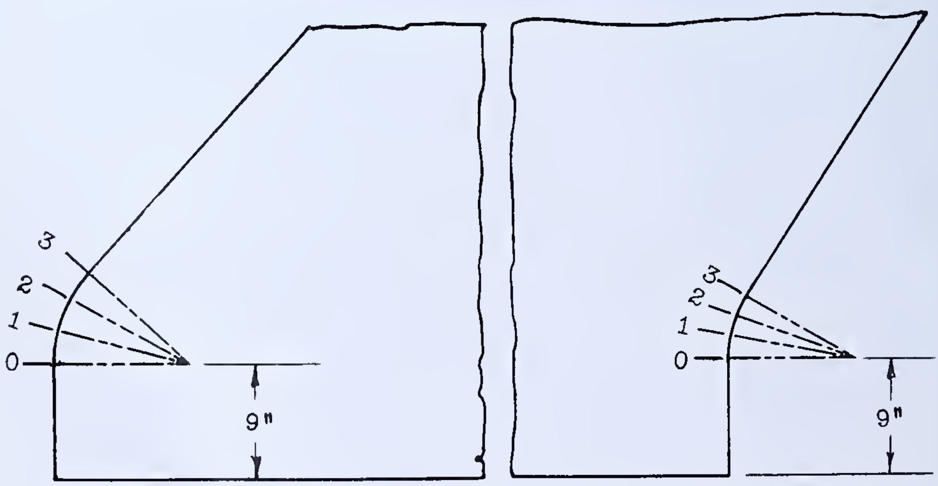


FIG. 345 — *Enlarged View of Base of Uptake Layout in Fig. 336*

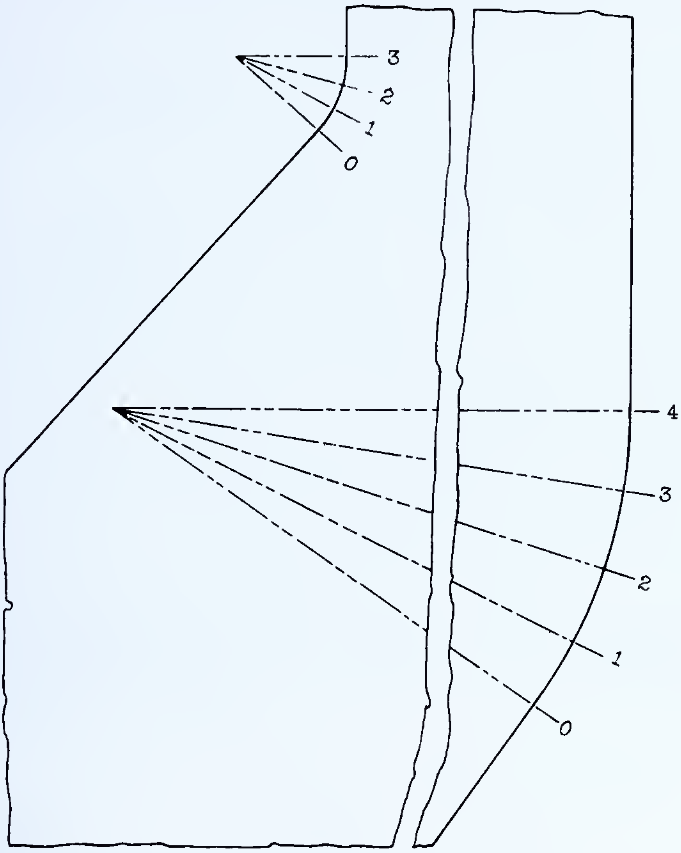


FIG. 346 — *Enlarged View of Top of Uptake Layout in Fig.* 336

(6) The locations of the lines at *d*, Fig. 343 are found by wheeling the distance from *0* to *3* (upper end) and dividing this distance (See Fig. 343) into three equal parts as shown at *d*, Fig. 344.

(7) The location of the top line in Fig. 343 is found by measuring in Fig. 336 from radial line *3* to the top.

If these measurements from Step 1 through Step 7 are taken carefully according to instructions, the flat plate, when formed on the horizontal lines, will fit against the outboard-starboard side of the uptake shown in Fig. 335. The same layout, but with the plate formed in the opposite direction, will produce a shape that will fit against the outboard-port side of the uptake shown in Fig. 335.

. Make a template for inboard-starboard plate. See Fig. 347.

Follow the same procedure outlined for making the outboard-starboard plate template.

Marking the Templates

When the templates have been laid out they are marked to show how many pieces are needed and the manner in which they should be formed. See Figs. 341, 343, and 347. The limits for the rolled curves are indicated by three center-punch marks as shown in Figs. 341, 343, and 347.

Laying Out the Steel Plates

After the templates have been completed and checked for approval, the steel plates are laid out. The template is placed in the correct position on the work and clamped. Weights are sometimes used to hold the template smoothly to the plate. A center punch is used to mark through the centers that were punched in the template. The contour is scribed with soapstone, and the template is removed from the plate.

White paint is used to define the burning line. The contour (defined by soapstone) is center-punch marked at 2″ intervals. A typical uptake-layout job is shown in process in Fig. 348. The necessary lettering is done with white paint.

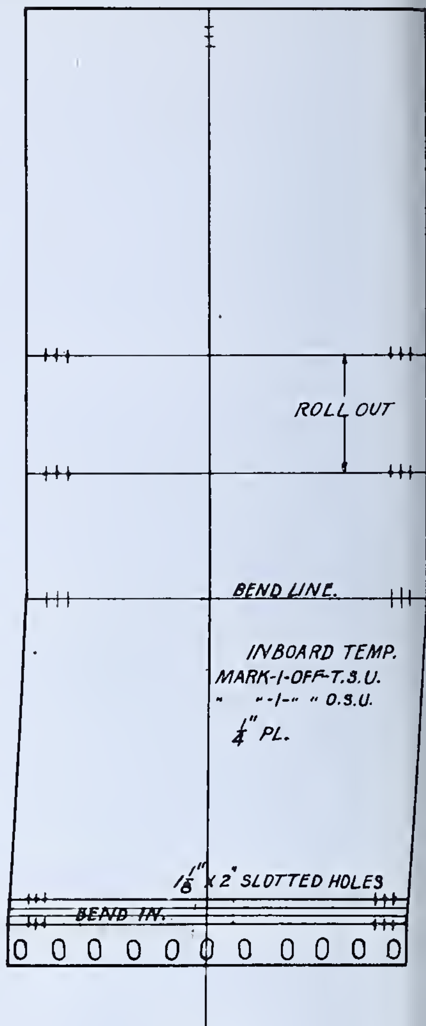


Fig. 347 — *Inboard Starboard Plate*

FIG. 348 — *Marking Off Section of Uptake From Template*

QUESTIONS

1. Why is it necessary to make a full size layout of the plates which form the uptake?

2. Explain what is meant by the words "base line"?

3. State the procedure for erecting a perpendicular on a base line.

4. How are measurements of length obtained along curved lines?

5. Why are all curved lines in this layout stepped off with dividers?

6. State the reason for center punching all bend lines?

7. For what reason is a plate marked "bend to template"?

PART VII
SHOP FABRICATION

JOB SHEET NO. 11
TO PREPARE A TRAY FOR A TOWER*

GENERAL INFORMATION

A tower is a cylindrical structure formed from ¾″ firebox steel. The plates are rolled in ten-foot sections and then welded where the circumferences butt together. The ends of the plates are beveled where they come together to be welded. The type of

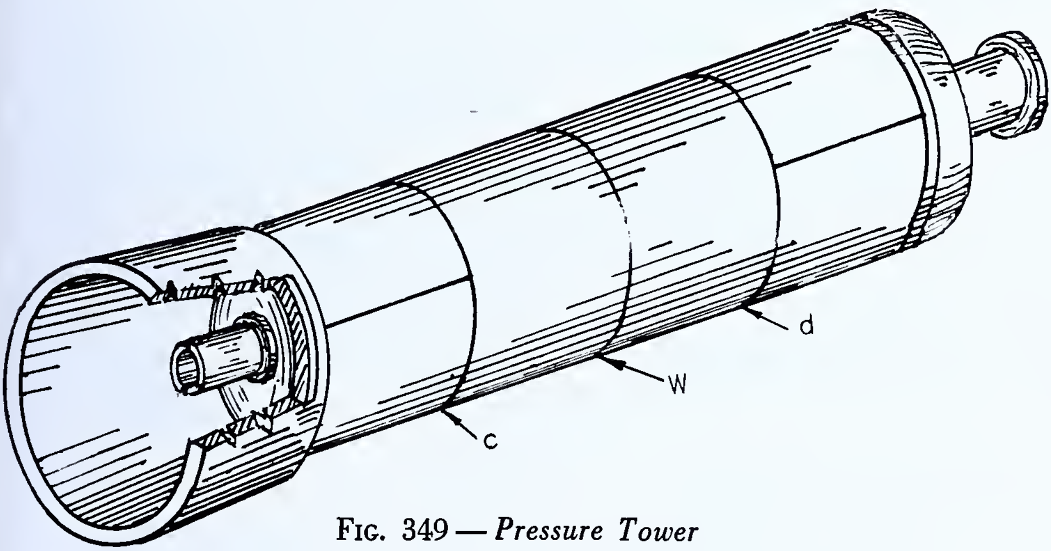


FIG. 349 — *Pressure Tower*

bevel used in preparing the plate ends is determined from the blueprint. It is either hand or unionmelt welding.

After the sections of the tower are rolled, they are welded together at *c* and *d* to form two cylinders; that is, the weld in the center Fig. 349 at *W* is welded after the other welds in the cylinder are finished.

A dished head is welded to each end

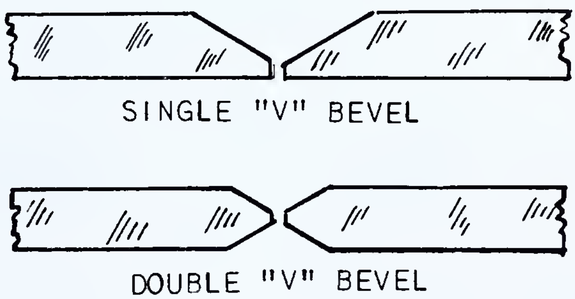


FIG. 350 — *Types of Weld Bevel*

*This typical example of Boiler Shop Practice is not intended for marine use.

of the cylinder, and suitable fittings are welded around the openings in the heads. The entire job is built up from the blueprint and a bill of material.

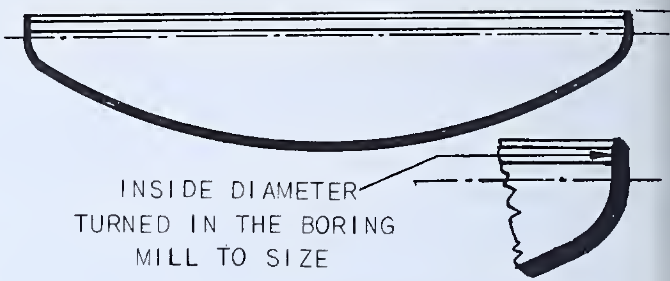


FIG. 351 — *Dished Head*

A tray (Fig. 352) is a circular plate about 3/8″ thick; it is perforated with a number of holes 7¼″. There are approximately twenty-five holes in a tray, and there are about twenty trays in a tower.

Preparing the Trays for Installation

Before the trays can be installed they must be straightened, the edges of the 7¼″ holes ground smooth, and two holes 7/16″ must be drilled on opposite sides of the holes 7¼″, to receive the bolts which hold the bubble caps in place. The 7/16″ holes have all been laid out and the holes 7¼″ have been burned out.

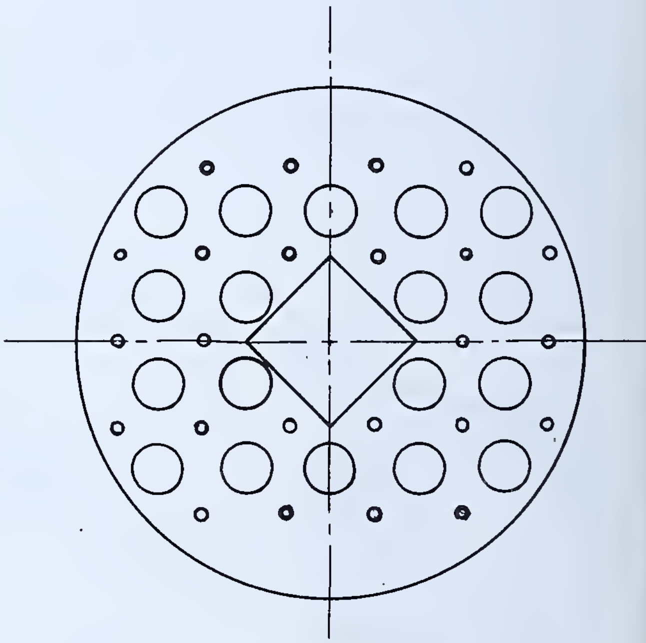


FIG. 352 — *Tower Tray*

The gauge shown in Fig. 353 is used to check the bolt holes that are drilled in the tray at opposite sides of the holes 7¼″. The flat bar with the rounded ends, which is welded to the main body of the gauge, registers in the hole 7¼″. The two pins, one at each end of the gauge, should register in the 7/16″ holes which are drilled for the bubble-cap bolts.

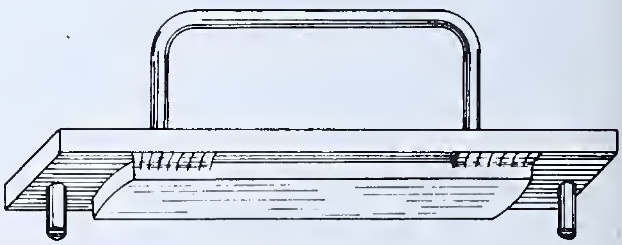


FIG. 353 — *Plug Gauge for 7/16″ Holes*

The plug gauge shown in Fig. 354 is used to check the sizes of the holes 7¼″. Two plug gauges like this are used to check these holes. One plug gauge is 7-3/16″ in diameter and the other is 7-5/16″. The skirt on the bubble cap is approximately 7-3/16″ in diameter. The plug gauge 7-3/16″ must GO through the hole in the tray. The plug

gauge 7-5/16″ must NOT GO through the hole in the tray. When the holes are ground on the inside edge so that the plug gauges fit in the manner explained, the holes will be the correct size to take the bubble-cap skirt.

Tools and Equipment

1. Air drilling machine
2. Portable grinder
3. Drilling stick
4. 5/16″ drill
5. 3/8″ drill
6. Surface grinder
7. Plug gauge Go-Not go: 7-3/16″ — 7-5/16″

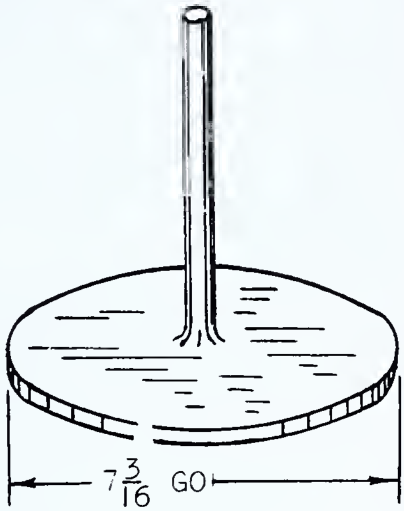


Fig. 354 — *Plug Gauge for 7¼″ Holes*

Procedure

1. Drill 7/16″ holes in the locations laid out.
2. Drill one 3/8″ drain hole in the location laid out.
3. Grind the internal circumference of the 7¼″ holes.

   Check with the plug gauge as the work proceeds. The holes must be round and true. The 7-3/16″ plug gauge must go into the holes. The holes must not be large enough for the 7-5/16″ plug to enter.
4. Remove all the burrs from the edges of the holes, and face off level for the bubble-cap gaskets. Use the surface grinder to do this job.

QUESTIONS

1. **Why must the 7¼″ holes in the tray be ground true?**
2. **What is the purpose of the plug gauge?**
3. **Why must the faces of the holes in the tray be surface-ground?**
4. **What precautions must be used to make sure the 7/16″ holes on opposite sides of the 7¼″ hole are kept in line?**
5. **How are the 7/16″ holes checked for alignment?**

JOB SHEET NO. 12
TO CHIP WELDING GROOVES

General Information

In the preceding Job Sheet, "Preparing a Tray for a Tower," the welding together of beveled-end plates was mentioned. It is the job of the chipper to cut grooves in the partially-welded joints to provide a good metal surface for what is known as "backwelding."

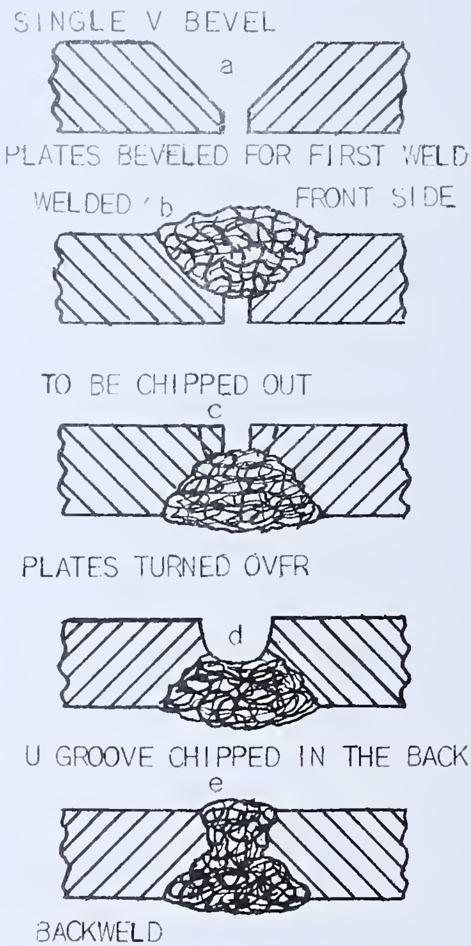


Fig. 355 — *Steps in Making a Weld and a Backweld*

A Backweld

A backweld is made on the reverse side of a joint after the first weld has been made on the front side. A weld and a backweld are shown in Fig. 355 at *e*. When the plates are prepared for welding, they are first beveled on the edges to be welded as shown in Fig. 355 at *a*.

The weld is made on the front side as shown in Fig. 355 at *b*. The plates are then turned over, and Fig. 355 at *c* shows the chipping line for the groove. A groove (Fig. 355 at *d*) is chipped the full length of the joint to be welded. The job is then backwelded as shown in Fig. 355 at *e*.

Determining the Type of Weld

The thickness of the plates to be welded usually determines the type of weld for which the plate is to be prepared. For a plate ⅝″ thick or less, the edges of the plate are prepared as shown in Fig. 356. Plates beveled in this way are manually welded.

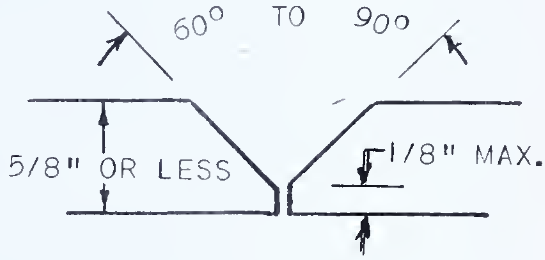


Fig. 356 — *Single V Weld*

After the vee is welded, the plates are turned over and the seam is chipped out as shown in Fig. 358 and Fig. 355. The blueprint specifications give the type of weld required. It is very important to have the edges of the plates prepared correctly.

Types of Welds

In that the boilermaker is responsible for preparing all plates for welding, it is necessary for him to know exactly what he is doing and why. The types of welds which follow should be carefully studied so that mistakes may be avoided.

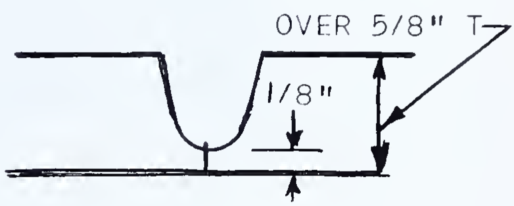
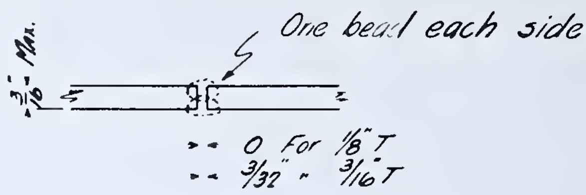
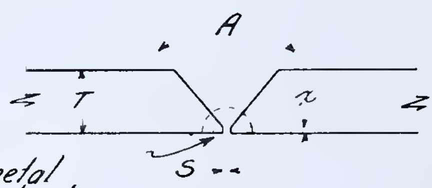


Fig. 357 — *Single U Weld*

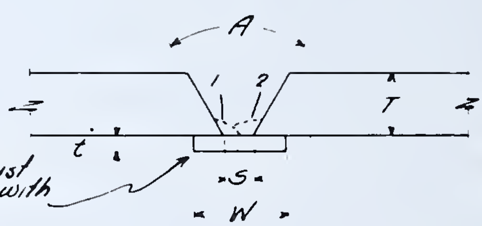
The single U weld shown in Fig. 357 is used on plates which are ⅝″ (or more) thick. The edges of the plates are prepared by planing a groove the shape of a U on each plate. See Fig. 359 for correct dimensions.





Chip to good metal before depositing back bead.

T	A	Min "S"	Max "Z"	Electrode Size
1/4	90°	1/16	1/16	5/32 - 3/16
5/16	90°	1/16	1/16	5/32 - 3/16
3/8	80°	1/16	1/16	5/32 - 3/16
7/16	80°	1/16	1/16	5/32 - 3/16 - 1/4
1/2	75°	3/32	1/16	5/32 - 3/16 - 1/4
9/16	75°	3/32	1/16	5/32 - 3/16 - 1/4
5/8	75°	3/32	1/16	5/32 - 3/16 - 1/4



For use where back bead cannot be deposited.

First two beads to be deposited as shown with smallest electrode size given.

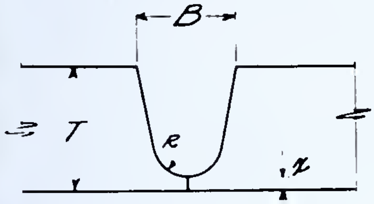
Backing strip must be in close contact with shell plates.

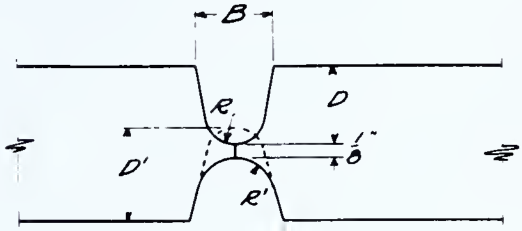
T	A	S	W	t	Electrode Size
1/4	90	3/16	5/8	1/8	1/8 - 3/16
3/8	80	3/16	5/8	1/8	1/8 - 3/16
1/2	60	1/4	3/4	1/8	5/32 - 3/16 - 1/4
5/8	60	1/4	3/4	1/8	5/32 - 3/16 - 1/4
3/4	50	1/4	3/4	1/8	5/32 - 3/16 - 1/4
7/8	45	1/4	3/4	1/8	5/32 - 3/16 - 1/4
1"	40	5/16	1"	3/16	5/32 - 3/16 - 1/4
1 1/8	40	5/16	1"	3/16	5/32 - 3/16 - 1/4
1 1/4	40	5/16	1"	3/16	5/32 - 3/16 - 1/4
1 1/2	35	5/16	1"	3/16	5/32 - 3/16 - 1/4

Note:- For intermediate thicknesses use values in tables for next higher thickness.

SCALE None	TITLE Welding Standards for Hand Welding of Pressure Vessels	APPROVED
MADE BY [signature]	SUN SHIPBUILDING & D.D. CO. CHESTER, PA., U. S. A.	SK-59-076
DATE 10/11/39		

Fig. 358 — *Welding Standards*





NOTE:- Use this detail above 7/8" only when stress relieved.
For intermediate thicknesses not given, take dimensions from next higher thickness.

T	B	x	R	ELECTRODE
11/16	11/16	1/8"	1/4	3/16"-1/4"
3/4	11/16	"	1/4	3/16"-1/4"
13/16	3/4	"	9/32	1/4
7/8	3/4	"	"	1/4
15/16	13/16	"	"	1/4
1"	13/16	"	"	1/4
1 1/16"	7/8	"	"	1/4
1 1/8	7/8	"	"	1/4
1 3/16	7/8	"	"	1/4
1 1/4	7/8	"	"	1/4
1 3/8	15/16	"	"	1/4
1 1/2	1"	"	"	1/4
1 5/8	1 1/16	"	"	1/4
1 3/4	1 1/16	"	5/16	1/4
1 7/8	1 1/8	"	"	1/4
2"	1 1/8	"	"	1/4
2 1/8	1 1/8	"	"	1/4
2 1/4	1 1/8	"	"	1/4
2 3/8	1 3/16	"	"	1/4
2 1/2	1 3/16	"	"	1/4
2 5/8	1 3/16	"	"	1/4
2 3/4	1 3/16	"	"	1/4
2 7/8	1 1/4	"	"	1/4
3"	1 1/4	"	"	1/4
3 1/4	1 1/4	"	"	1/4
3 1/2	1 1/4	"	"	1/4

NOTE:-
This detail to be used:-
(1) From 7/8" to 1 1/4 on joints not stress relieved.
(2) Above 3 1/2"
(3) for intermediate thicknesses where minimum distortion is allowable.

T	D	B	R	D'	B'	R'	ELECTRODE
1"	1/2	1/2	1/4	5/8	5/8	5/16	3/16-1/4
1 1/16"	9/16	9/16	"	11/16	11/16	"	3/16-1/4
1 1/8"	9/16	9/16	"	11/16	3/4	"	3/16-1/4
1 3/16"	5/8	5/8	"	3/4	3/4	"	3/16-1/4
1 1/4"	5/8	5/8	"	3/4	3/4	"	3/16-1/4
1 3/8"	11/16	11/16	"	13/16	13/16	"	3/16-1/4
1 1/2"	3/4	11/16	"	7/8	13/16	"	3/16-1/4
1 5/8	13/16	3/4	9/32	15/16	13/16	11/32	1/4
1 3/4	7/8	3/4	"	1"	7/8	"	1/4
1 7/8	15/16	13/16	"	1 1/16	7/8	"	1/4
2"	1"	13/16	"	1 1/8	7/8	"	1/4
2 1/8"	1 1/16	7/8	"	1 3/16	15/16	"	1/4
2 1/4	1 1/8	7/8	"	1 1/4	15/16	"	1/4
2 3/8	1 3/16	7/8	"	1 5/16	15/16	"	1/4
2 1/2	1 1/4	7/8	"	1 3/8	1"	"	1/4
2 5/8	1 5/16	15/16	"	1 7/16	1"	"	1/4
2 3/4	1 3/8	15/16	"	1 1/2	1 1/16	"	1/4
2 7/8	1 7/16	1"	"	1 9/16	1 1/16	"	1/4
3	1 1/2	1"	"	1 5/8	1 1/16	"	1/4
3 1/4	1 5/8	1 1/16	"	1 3/4	1 1/8	"	1/4
3 1/2	1 3/4	1 1/16	5/16	1 7/8	1 1/8	3/8	1/4
3 3/4	1 7/8	1 1/8	"	2"	1 1/8	"	1/4
4	2"	1 1/8	"	2 1/8	1 1/8	"	1/4
4 1/4	2 1/8	1 1/8	"	2 1/4	1 3/16	"	1/4
4 1/2	2 1/4	1 1/8	"	2 3/8	1 3/16	"	1/4

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MADE BY [illegible]	SUN SHIPBUILDING & D.D. CO.	CHESTER, PA., U. S. A.	SK 59-077
DATE 10/11/39			

FIG. 359 — *Welding Standards*

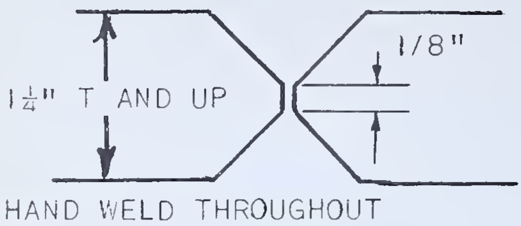

Fig. 360 — *Double V Weld*

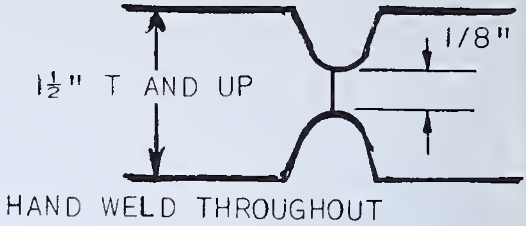

Fig. 361 — *Double U Weld*

A job prepared for a double V weld is shown in Fig. 360. Plates that are 1¼″ or more thick are prepared in this manner.

A double U-grooved job is shown in Fig. 361. Plates that are 1½″ or more thick are prepared in this manner.

All of the above mentioned welds are to be chipped on the back side (See Fig. 355 at *c* and *d*) before welding the second U.

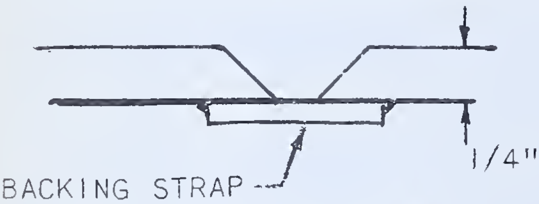

Fig. 362 — *Back-Strap Weld*

The back-strap weld shown in Fig. 362 needs no welding on the second side. The back strap is tack welded under the groove formed by the vees, and it is left on after the welding is completed. Plates of about ¼″ thick are back-strap-welded. The back strap prevents the welding torch from "blowing through" as the welding progresses.

The double V weld is used on plates of ⅝″ or more in thickness. Both sides of a double V weld are unionmelt welded. Unionmelt welded means that the job is done with an automatic welder. The plates are prepared as shown in Fig. 363, and the 45°- to 60°-angle side of the joint is welded first.

Another type of double V weld is shown in Fig. 364. The 90°-angle side is first welded by hand (manual weld). The plates are then turned over, and the 60°-angle side is unionmelt welded.

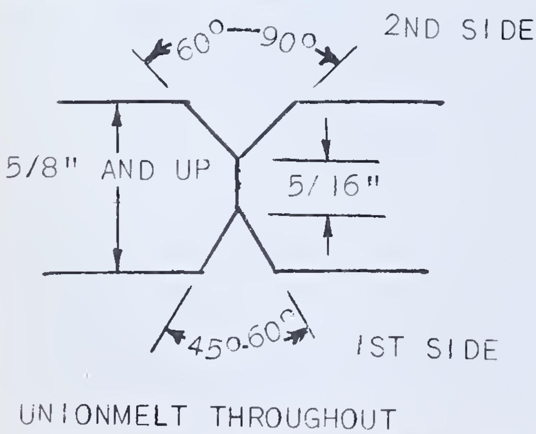

Fig. 363 — *All Unionmelt Welded*

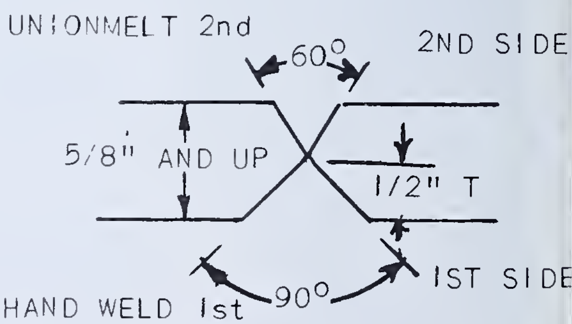

Fig. 364 — *Hand and Unionmelt*

Welding Plates vs. Cylinders

When flat plates are welded together while lying on the floor, they are turned over when the second side is welded. When the welds shown in the foregoing illustrations are made on cylinder seams, inside of tanks, or other such jobs, the welder works from both sides of the job. He has to climb inside of the cylinder or tank to finish the job.

Welds made along the seam of a tank or cylinder from end to end are called LONGITUDINAL WELDS. Welds made around a circumference seam or around sides of a tank are called GIRTH WELDS.

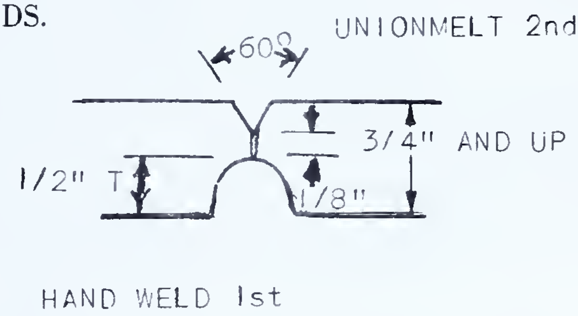

Fig. 365 — *Hand and Unionmelt*

Tools and Equipment

1. Chipping chisels
2. Pneumatic hammer (if required)
3. Plate planer (if required)
4. Cutting tools
5. Necessary templates

Procedure

1. Identify on the blueprint the correct type of weld for which the edge of the plate is to be prepared.
2. Place and secure the job in the correct position to be planed or chipped.
3. Obtain the correct cutting tool and equipment to be used.
4. Obtain necessary gauges and templates.
5. Try the equipment to find if it is in good working condition.
6. Proceed with the job according to instruction.
7. Have the job checked for accuracy when completed.

QUESTIONS

1. **Why are plate edges beveled for welding?**
2. **Name the several types of bevels or grooves that are planed or chipped in the edges of plates that are to be welded.**
3. **What are the relative strengths of lap-welded joints and butt-welded joints?**
4. **What is understood by the "lip" on a steel plate that has been planed or chipped along the edge?**
5. **When should the lip be "chipped-out" to good metal?**
6. **Name the methods used to bevel plate ends.**
7. **What is a backing strip?**
8. **When and where is a backing strip used?**
9. **Do the plate ends require a lip when backing strips are used?**
10. **Describe a hand-welded V-butt seam inside and a unionmelt weld outside.**
11. **Describe a hand-welded U-butt seam inside and a unionmelt weld outside.**
12. **Is the lip chipped to good metal in Question 11?**
13. **What is the straight seam of a shell called?**
14. **What is the seam called that runs around the circumference of a cylindrical shell?**
15. **What is "backwelding"?**
16. **What method of welding requires backchipping and backwelding?**

JOB SHEET NO. 13
TO FIT A DISHED HEAD TO A CYLINDER FOR WELDING*

General Information

After flat plates are rolled to shape for making cylinders, they must be prepared for welding along the longitudinal seam. The longitudinal seam is shown in Fig. 138, "*Machine Operation No. 1.*" The edges of the plate that butt together have been beveled for a single-vee butt weld. See Fig. 366.

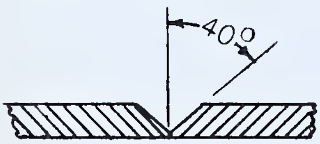

Fig. 366 — *Single-Vee Bevel.* See Fig. 369 at 5

It is not possible to roll a cylinder from a flat plate and have the ends meet evenly as shown in Fig. 138. The edges at the cylinder ends will probably be uneven as shown by the register marks *a* and *b* in Fig. 367. Mark *b* must be drawn over in line with mark *a*.

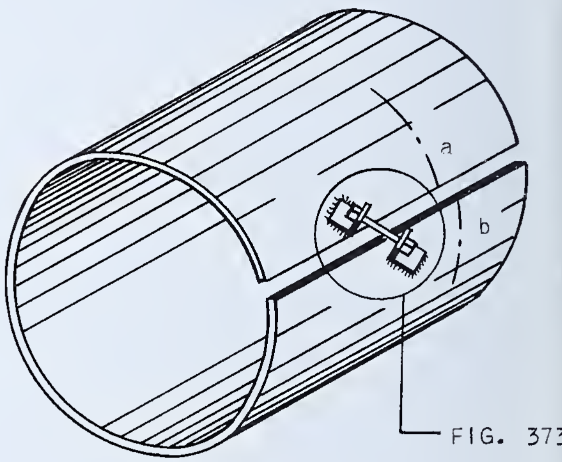

Fig. 367 — *Drawing the Cylinder Ends Even and the Joint Tighter*

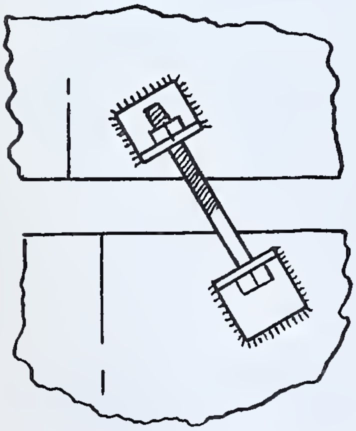

Fig. 368 — *Angle Clips for Drawing Joint Tight.* See Fig. 369 at *2*

In order to draw the ends together evenly, the boilermaker welds a pair of angle clips (See Fig. 372) to the rolled plate as shown in Fig. 368, passes a 1″ bolt through the holes in the clips, and draws it up until the joint is tight.

* This typical example of Boiler Shop Practice is not intended for marine use.

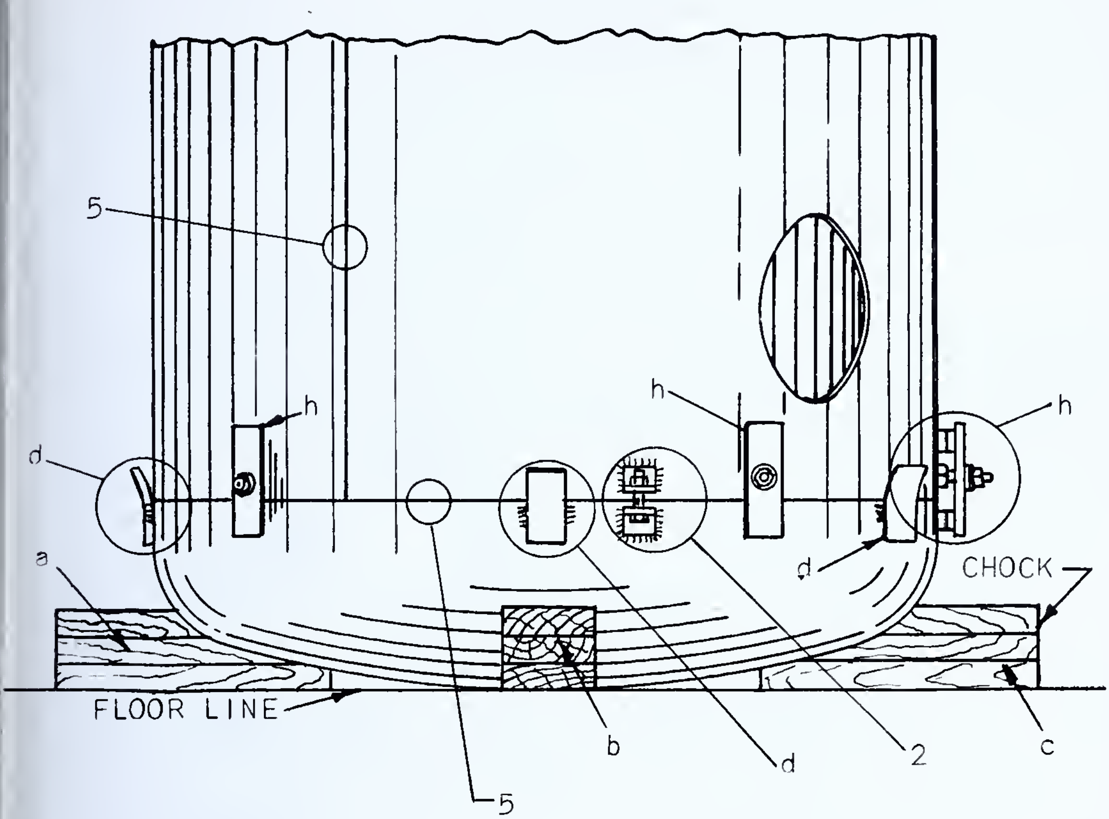

Fig. 369 — *Fitting the Cylinder and the Dished Head*

Wheeling the Circumference

The inside diameters of all dished heads are turned according to the blueprint dimensions. Since the diameter of the cylinder and the inside diameter of the head may vary, it is considered good practice to "wheel" (measure with the measuring wheel) the inside circumference of both shell and head, or, measure with the conversion tape the outside circumference of both cylinder and head to determine the amount of offset (See Fig. 370) to expect, if any.

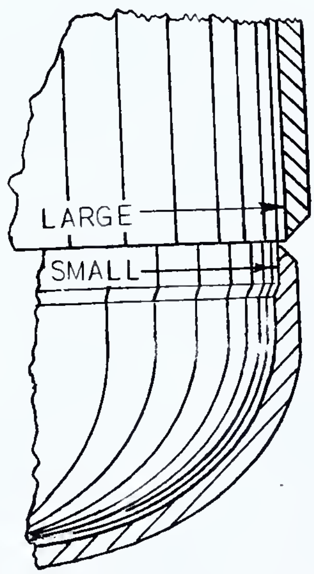

Fig. 370 — *Offset of Cylinder and Head*

Calculating the Offset

If there is any appreciable difference between the circumferences, the amount of offset is determined as follows:

Assume the difference in circumference to be 3/8″.
Reduce 3/8″ to a decimal and divided by 3.1416.
The result will be the amount of the offset.
.375 divided by 3.1416 equals .1193, or approximately 1/8″.

This figure means that the cylinder will overlap the head 1/8″ all around. Since the outside circumferences of the parts are not absolutely true and smooth, they must be fitted or aligned as evenly as possible by means of the locating straps shown in Fig. 369.

Aligning the Cylinder Walls

It is possible to force the cylinder wall inward by means of the strap and bolt shown at *h* in Fig. 369. A detail of the strap and bolt is shown in Fig. 371. When it is found necessary to force the cylinder wall outward, weld a 1″ bolt to the shell as shown. Place a suitable strap over the bolt and place large nuts under the ends of the strap as shown in Fig. 371. Drawing the nut down on the bolt will force the cylinder shell in the required direction.

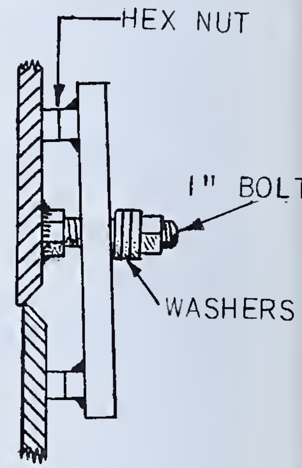

Fig. 371 — *Adjusting Bolt.* See Fig. 369 at *h*

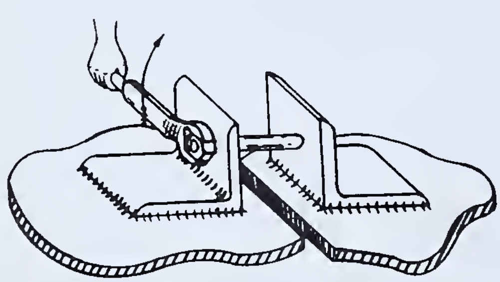

Fig. 372 — *Detail 2 in Fig.* 375 *and Fig.* 369

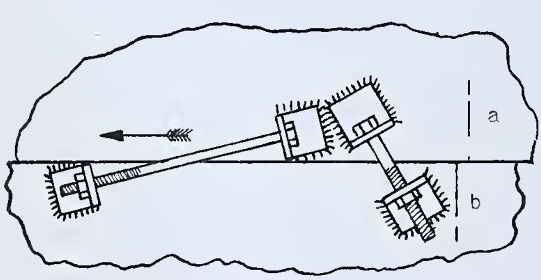

Fig. 373 — *Evening the Register Lines* (*a with b*)

If the joint meets before the ends come even, which is sometimes the case, another pair of angle clips is welded to the cylinder on opposite sides of the seam. Weld the clips as close to the joint as possible. Pass a 1″ bolt through the clips and draw it up until the required fit is obtained. See Fig. 373.

In case one side of the butted joint in the cylinder drops below the opposite side, it can be brought into line by one of two methods.

1st method. Use a C clamp and formed pieces of heavy flat bar. Place the curved flat bars as shown

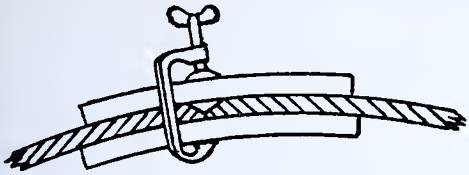

FIG. 374 — *Aligning Joints with a C Clamp and Curved Bars*

in Fig. 374, and pull them tightly to the surface of the cylinder shell. This method is used on light stock and at the ends of a cylinder when the center butts before the ends come together.

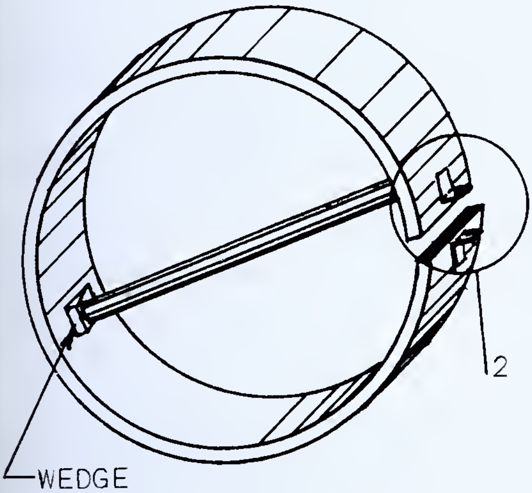

FIG. 375 — *Aligning the Edges of the Joint with a Pipe and a Wedge*

2nd method. Use a piece of pipe and wedge as shown in Fig. 375. Tack weld the wedge under the end of the pipe, and drive the wedge and the pipe in far enough to bring the edges of the joint even. The joint is then tack welded, and the pipe is moved to a new position. The tack welding is done on the side of the plate that is to be welded last. This side is determined by the type of welded joint specified on the blueprint.

After the cylinder or cylindrical steel section has been welded, the aligning clips are removed and the weld is chipped and cleaned. The cylinder must now be rounded. This is done by re-rolling the cylinder or by having it "set up" on a bull-riveter. The bull-riveter presses the cylinder along the longitudinal seam or any part of the shell section that does not conform to the sweep of the circumference. When the cylinder has been prepared up to this point, it is ready to have the dished head fitted to it.

Fitting the Dished Head

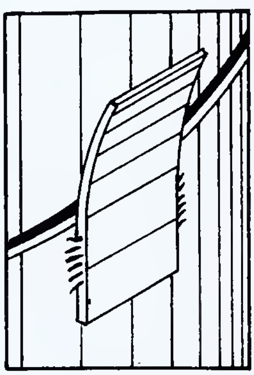

FIG. 376 — *Locating Strap.* See Fig. 369 at *d*

Figure 369 shows a cylinder and a dished head in course of being fitted. The dished head is supported level by four wooden chocks, three of which appear at *a*, *b*, and *c*. Four straps are tack welded to the head as shown at *d*. See detail of straps in Fig. 376. These straps are for the purpose of keeping in line the outside diameters of the cylinder and the dished head. The straps are tack welded to the head on the correct center lines (lead markings) which are indicated by white-paint markings on the cylinder and head. The markings have been previously located according to the blueprint.

Tools and Equipment	Materials
1. 1″ spud wrench	1″ bolts
2. Impact wrench	Quantity of 1″ salvaged nuts
3. 8-lb. maul	Straps
4. 12″ steel straightedge	Clips
5. Measuring wheel (or tape)	Washers
6. Folding rule	Soapstone

Procedure

1. Set the dished head on the floor, and with wooden wedges chock it level as shown in Fig. 369.
2. Wheel the inside circumference of the dished head to determine the offset between the head and shell sections at the seam.

   Divide the difference between the two circumferences by 3.1416; the result will be the amount of overlap on a side. Regulate the setting of the shell on the dished head accordingly.
3. Tack weld four or six straps (See Fig. 369, detail *d*) at regular intervals to the dished head.
4. With the crane, set the shell section on the dished head as shown in Fig. 369.

   Select the correct shell section and place it on the dished head according to the lead-line and center-line markings, *T-1, T-2,* etc., which are found painted on the shell section.
5. Adjust the shell circumference to the dished-head circumference.

   The adjustment is made with the straps and bolts. See detail *h,* Fig. 369.
6. The weight of the shell is usually sufficient to make the edges come together and leave the correct amount of space for welding. In cases where the joint must be drawn together, angle clips are used as shown in Fig. 368. The clips are tack welded to bring the bolt at right angles to the joint.
7. Tack weld at 18-inch intervals around the circumference of the shell and head joint.

   The tack welds are made three inches long, and they are made on the inside or outside, depending upon the type of weld shown on the blueprint.
8. Remove all straps, bolts, and clips.
9. Proceed to align and tack weld the next section. (There are several sections required for some jobs.)

QUESTIONS

1. What is meant by the "longitudinal seam" of a cylindrical tower section?
2. What methods are used to bring even, the ends of a longitudinal seam or the register marks on the joint?
3. Explain how a longitudinal-seam joint is pulled up tightly.
4. State the procedure followed to make a tight longitudinal-seam joint when the center of the joint butts together while the ends of the joint remain open.
5. Explain how to align the edges of a longitudinal-seam joint when one edge is lower than the other (overlap).
6. What is meant by "lead-line markings"?
7. State the purpose of the center lines on a shell diameter.
8. On which center lines are the lead-line markings found?
9. When a cylindrical shell is being fitted to a dished head, what other procedures are necessary besides setting the shell on the head according to the center-line markings and welding aligning straps to the head?
10. Explain the purpose of locating-straps which are welded to one side of a dished head.
11. When are locating-straps welded to one side of a dished head?
12. Explain the use of adjusting-straps and bolts.
13. State the method used to determine the amount of offset (if any) for which to allow when fitting a cylindrical shell to a dished head.
14. If the difference between the inside circumferences of a dished head and a cylindrical shell is 9/16″, how much offset will there be all around the joint between them?

JOB SHEET NO. 14
TO FIT GIRTH SEAMS FOR WELDING*

General Information

Girth seams are welded when the cylindrical shell is lying in a horizontal position as shown in Fig. 377. The work is blocked up on the floor until the longitudinal alignment is correct. Angle clips are tack welded on the circumference of the shell as shown in Fig. 377, detail *2*. See Fig. 372, Job Sheet No. 13. Flat clips are tack welded on the circumference as shown in Fig. 377, detail *4*. See Fig. 376, Job Sheet No. 13.

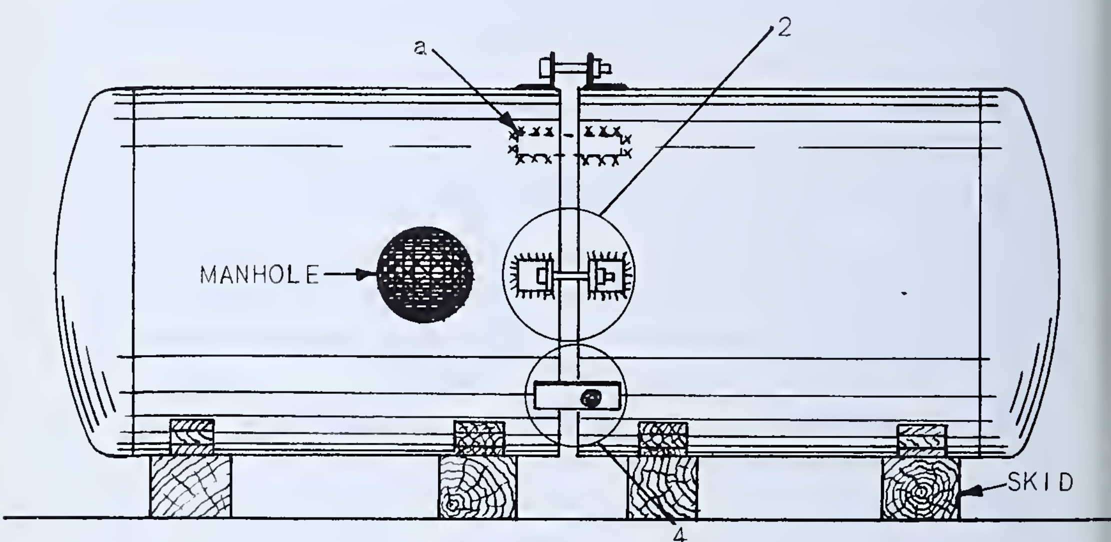

Fig. 377 — *Cylindrical Shell in Preparation for a Girth-Seam Weld*

Aligning the Girth Joint

The alignment of the girth joint is made possible by pulling up on the bolts in the angle clips and drawing the two sections of the shell together as shown in Fig. 377. Tack welds are made at intervals in the manner explained in Job Sheet No. 13. All fittings on a job of this nature must be done on the outside of the shell. Skids are placed at intervals along the floor. The skids are long enough to permit the cylinder to roll a considerable distance either way. The radius blocks (or chocks) are placed securely after each movement of the cylinder on the skids.

Safety

Care must be taken to secure the radius blocks *r* (shown in Fig. 379) under the cylindrical shell, properly, to keep the work from rolling. This type of shell weighs from 15 tons to 35 tons, and serious injuries can be caused by careless blocking.

* This typical example of Boiler Shop Practice is not intended for marine use.

Tools and Equipment	Materials
1. 1″ spud wrench	1″ bolts
2. Impact wrench	Quantity of 1″ salvaged nuts
3. 8-lb. maul	Straps
4. 12″ steel straightedge	Clips
5. Measuring wheel (or tape)	Washers
6. Folding rule	Soapstone

To Fit a Center Girth Seam for Welding

Procedure

1. Block the cylindrical shell sections in alignment (as shown in Fig. 377). Use radius blocks and skids.
2. Check the lead lines and center lines on the adjoining edges to be tack welded, to be sure that the joint is aligned correctly.
3. Tack weld three or more sets of angle clips to the shell as shown in Fig. 377, detail *2*.
4. Insert bolts in clips, and draw shell joint together until the seam is tight.
5. Adjust the alignment of the circumferences until the surfaces of the shell are in the same plane.

   Use straps shown in Fig. 377, detail *4*, to make this adjustment.
6. Tack weld the joint between the shell sections at intervals of 18″.

   The tack welds are made on the inside or outside depending on the type of weld shown on the blueprint.

   Make tack welds 3″ long. Tack weld as far as possible around the circumference, up and down, before rolling the shell.
7. With the crane, roll the shell a sufficient amount for the tack welding to be continued.

   On heavy tanks, the tack welds should be reinforced by welding straps across the seam as shown in Fig. 377 at *a*. This reinforcing job must be done only after the joint has been pulled up as in Step 4. Use as many welding straps as are necessary.
8. Finish the tack welding.
9. Remove all bolts, clips, and straps except the special reinforcing straps.
10. Proceed to weld the girth seam.

End Girth Seam

In that cylindrical tanks are often composed of several sections, the over-all longitudinal measurement of the finished job may be thirty feet or more. Since many

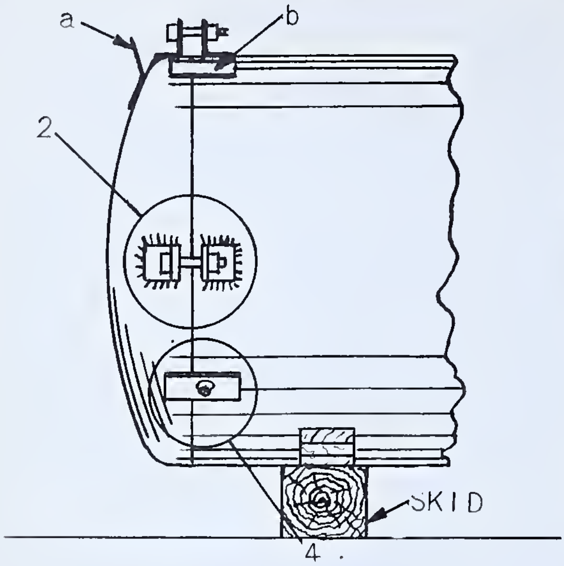

FIG. 378 — *Fitting the Dished Head with the Shell in a Horizontal Position*

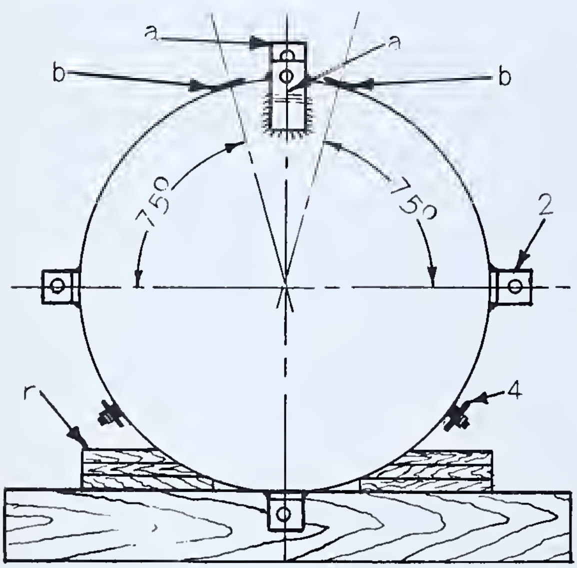

FIG. 379 — *End View of Tank*

such tanks have tubes and other fabricated units installed inside, it is not possible to fit the dished head as described in Job Sheet No. 13. In preparing this sort of unit for welding the girth seam between the dished head and the end of the shell, the dished head is fitted while the shell is lying in a horizontal position as shown in Fig. 378. An angle strap is welded to the dished head as shown in Fig. 378 at *a*. This strap has a hole in which to insert the crane hook for lifting the head. Two flat straps shown at *b*, Fig. 378, are welded about 30° apart on the circumference of the dished head as shown at *b* and *b* in Fig. 379. The straps *b* and *b* serve as guides when the head is swung into place. When the head is in place as shown, four or more angle clips are welded to the head and to the shell. See detail *2*, Fig. 378. The end view of the tank, Fig. 379, shows detail *2* and detail *4*.

The inside circumference of the head has been "wheeled" and the measurement compared with the inside circumference of the shell to find the amount of offset, if any. The head is pulled up to a good joint with the shell, and by means of the strap and welded bolt shown in detail *4* the job is adjusted concentrically with the shell.

Tack welds are made to secure the position of the head when the angle clips and straps are removed. The general procedure is given as follows:

To Fit an End Girth Seam for Welding

Procedure

1. Weld angle clip in place as shown in Fig. 378 at *a*.
2. Weld locating straps in position as shown in Fig. 379 at *b* and *b*.
3. Wheel the inside circumferences of the head and the shell to find the offset, if any.
4. With the crane, swing the head into position.

5. Weld angle clips in place as shown in Fig. 379 at detail *2*.
6. Weld bolts in place for adjusting straps as shown in detail *4*.
7. Pull the head tightly to the end of the shell, and adjust for alignment by means of straps.
8. Tack weld at intervals of 18″ around the seam.

   The tack welds are about 3″ long and are made on the inside or outside depending upon the type of weld shown on the blueprint.
9. Remove all straps, bolts, and clips.

QUESTIONS

1. **What is the purpose of the angle strap which is welded to the dished head in Fig. 378?**
2. **What provision is made for guiding and locating the dished head when it is being fitted to the shell?**
3. **Name the location of the circumferences on the diameters of which the fitting is usually based.**
4. **What means is provided by which a mechanic may enter the tank?**
5. **How should the blocking be arranged before the tank can be rolled with safety?**
6. **Explain the procedure for rolling the tank along the skids when a seam is being fitted.**
7. **How far apart are tack welds made on this type of job?**
8. **State the length of tack weld generally considered sufficient for this type of job.**

JOB SHEET NO. 15

TO FIT AND INSTALL TRAYS IN A CYLINDRICAL TANK*

General Information

A cylindrical tank similar to the one shown in Fig. 377 is to be equipped with a number of steel trays like the one shown in Fig. 352, Job Sheet No. 11. The trays rest upon, and are welded to, angle-iron rings that have previously been welded at intervals on the inside of the cylindrical shell.

Cutting the Angle Ring

An angle ring in process of being cut to size is shown in Fig. 380. The steel angle is formed to the correct diameter. The ends are left long enough to trim off the straight ends that are not formed. After the ring is formed, it is laid on a

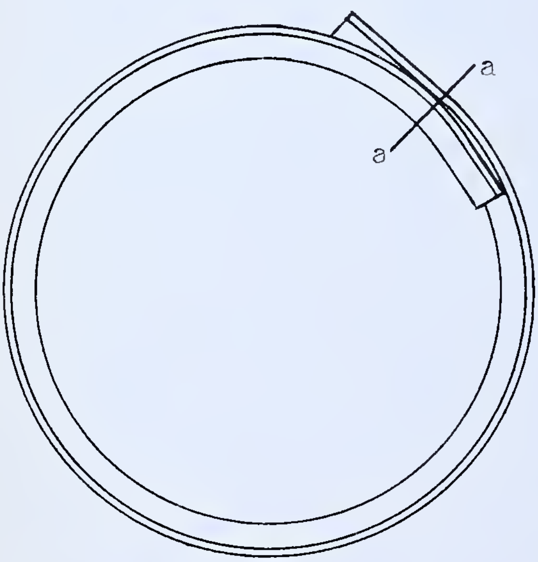

Fig. 380 — *Angle Ring in Process of Being Cut to Size*

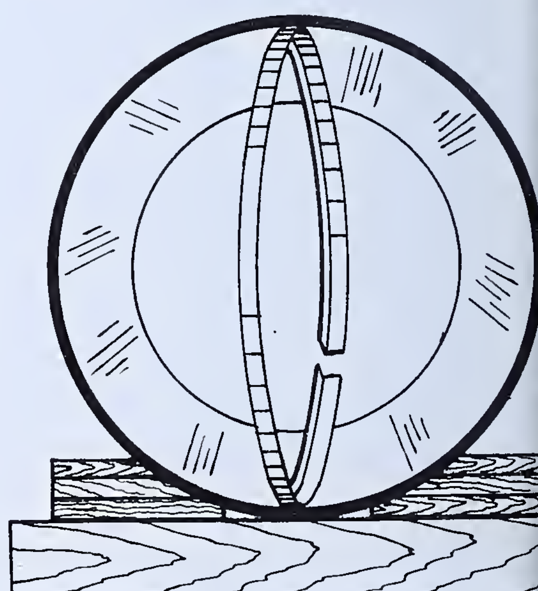

Fig. 381 — *Pushing the First Ring into Place*

flat surface, expanded to the correct diameter, and marked to be cut as shown by the line *a-a* in Fig. 380. This is the correct method to use for a quick, accurate job. The ring is then pushed into the cylinder as shown in Fig. 381. The first ring is always pushed into the location farthest away from the open end to allow subsequent rings to be placed.

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* This typical example of Boiler Shop Practice is not intended for marine use.

Setting to Lead Lines

On the inside of the cylinder (or tower) will be found lead lines and ring locations. See Fig. 382. The joints in the rings are not in line, one with the next. They are set with the lead lines according to the information given on the blueprint. Be careful to follow this information.

After the rings are pushed into the correct location, they are turned around to lie against the inside of the cylinder as shown in Fig. 383.

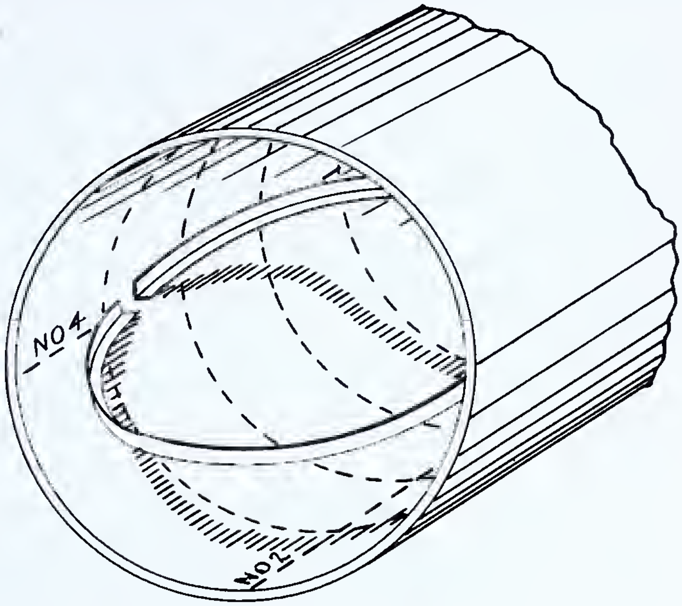


Fig. 382 — *Turning the Ring into Position*

Holding the Cylinder Round

When the trays are all in place they act as stiffeners to keep the cylinder (or tower) round. Since it is unsupported at the open end except by its walls as it lies in a horizontal position, the cylinder has a tendency to sag out-of-round. To prevent this condition, it is usual to support the walls of the shell with pipe struts. After the first ring is pushed into place, several struts are wedged into the shell diameter. The diameter is checked with a measuring stick, and the struts are adjusted until the shell is round. This procedure is repeated as often as necessary during the installation of the rings and trays.

Spreading the Ring

A piece of pipe, which has a wedge tack welded to one end, is used as a spreader to force the angles tightly against the shell. The pipe is made to a length which will allow it to be knocked free when desired. A tack weld is made on the toe of the angle at a point close to the pipe end and at 18″ intervals all around the inside of the shell. The end of the pipe is "stepped" as shown in Fig. 384, which allows the toe of the angle to be reached easily with the welding rod.

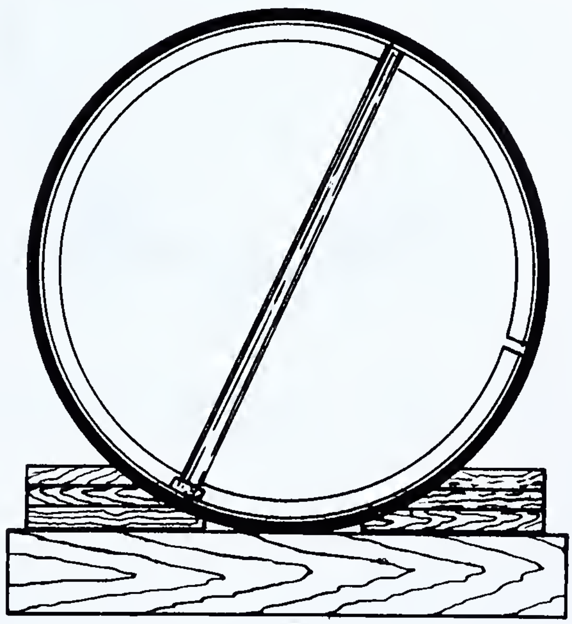


Fig. 383 — *Ring Held in Position for Tack Welding*

Care must be taken during the tack welding operation to keep the ring on

the line location and tightly pressed against the shell.

After the ring is tack welded all around, the pipe is removed and usually a weld is made all around the heel of the angle against the shell. The blueprint specifies the type of weld and the location.

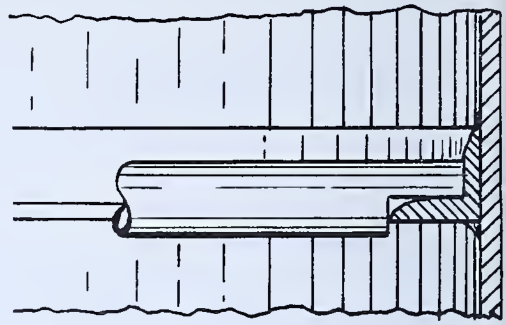


Fig. 384 — *Stepped Pipe End*

Installing a Tray

As soon as a ring has been welded in place, a tray is installed, as shown in Fig. 385 at *x*. The tray is pushed into the shell and laid against the angle ring. It is centered in the shell to clear the inside by approximately the same distance all around. When the tray is centered

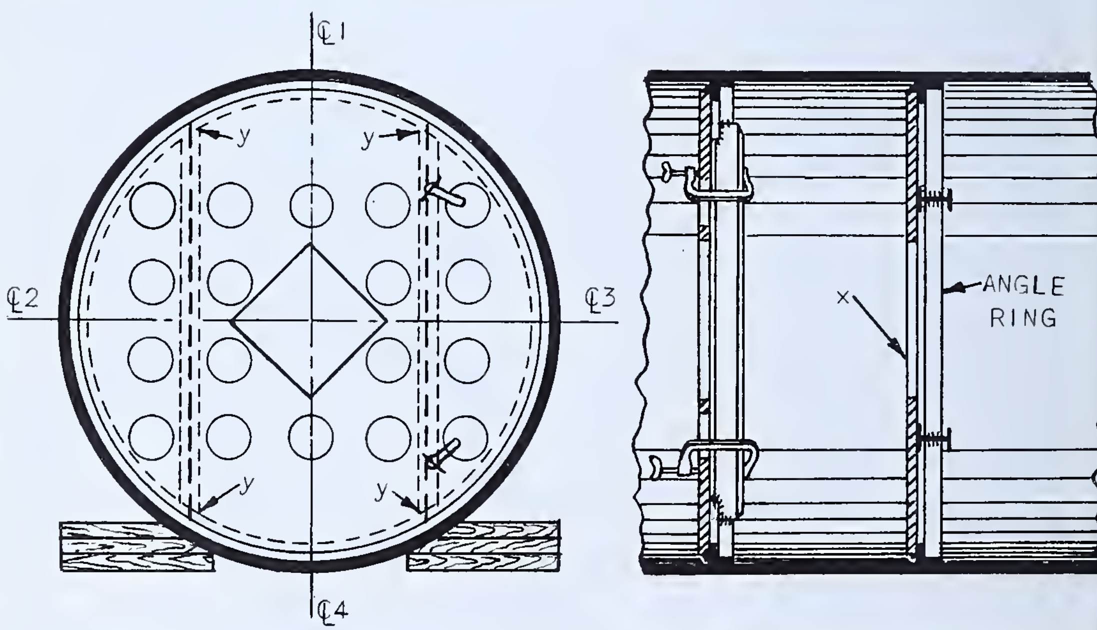


Fig. 385 — *A Tray Installed on Angle Ring*

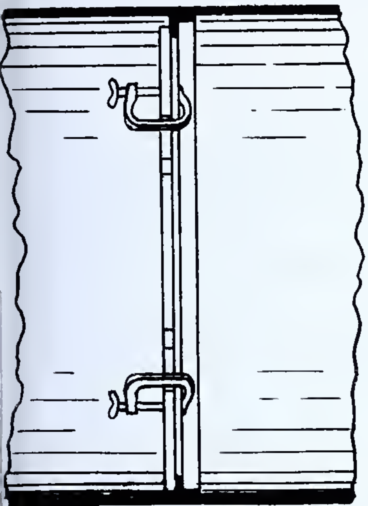


Fig. 386 — *Tray Clamped to Angle Ring with C Clamps*

satisfactorily, it is clamped into place with C clamps as shown in Fig. 386. The trays are installed in alignment with the center lines, which are found in all cylindrical shells. The center lines on the trays must match the center lines on the shell.

The tray is tack welded according to the information given on the blueprint. These tack welds are made at four points shown by *y* in Fig. 385. Study Fig. 385 carefully. The left-hand view shows two I-beam supports reaching across the shell from side to side. These I beams support the trays. The tack welds mentioned above are made from the tray to the toe of the angle ring at the I-beam locations as shown.

Installing I Beam Supports

Place the I beam under the tray at the location shown on the blueprint. The ends of the I beam are "coped out" (cut away) to allow it to meet the tray snugly. The face of the I beam and the face of the angle ring must be "flush." Clamp the I beam fast with C clamps, and have the ends of the I beam welded to the shell. The rest of the angle rings, trays, and I-beam supports are installed in the same manner.

The general procedure for fitting and installing trays is given as follows:

Procedure

1. Expand the angle ring to the correct diameter, and cut the ends as shown in Fig. 380.
2. Push the ring into the shell as shown in Fig. 381.
3. Turn the ring into position and locate it according to information given on the blueprint.
4. Spread the ring by means of a pipe spreader as shown in Fig. 383.
5. Tack weld the toe of the angle to the shell at a point close to the end of the spreader.
6. Adjust the spreader to a new position, and tack weld 18″ from the first tack weld.
7. Continue to tack weld all around as in Step 6.
8. Remove the spreader.
9. Push the tray into place on the ring.
10. Center the tray with the shell and make sure it registers with the center lines.
11. C-clamp the tray to the ring.
12. Tack weld at four points as shown in Fig. 385.
13. Place I-beam support as shown on the blueprint, and clamp with C clamps.
14. Weld the ends of the I beam to the shell as shown on the blueprint.
15. Remove the C clamps.

QUESTIONS

1. Explain how the angle ring is cut to the correct size.
2. Where are the locations for the angle rings found on the cylinder (or tower)?
3. How is the angle ring fitted into the cylinder before the tack welding is done?
4. State how the joints in the angle rings align, one joint with the next.
5. State whether the angle ring or the tray is installed in the cylinder first.
6. Explain how the tray is fitted to the angle ring.
7. What is the correct relationship between the center lines on the tray and on the cylinder shell?
8. How is the open portion of the cylindrical shell kept round while the ring and tray installations are being made?
9. How much coping is required on the I-beam ends to insure a good fit?
10. At what points are the trays tack welded to the angle ring?
11. Why are the tack welds made at this particular location?
12. How will a poorly fitted I beam affect the alignment of the trays?
13. On what center lines are the trays located for correct alignment?

JOB SHEET NO. 16
TO INSTALL MANHOLE NOZZLES*

General Information

Pressure tanks must be repaired occasionally, and they must be cleaned and inspected periodically. To provide access to the interior of the tank, the boilermaker welds a manhole into an opening in the shell as shown in Fig 387.

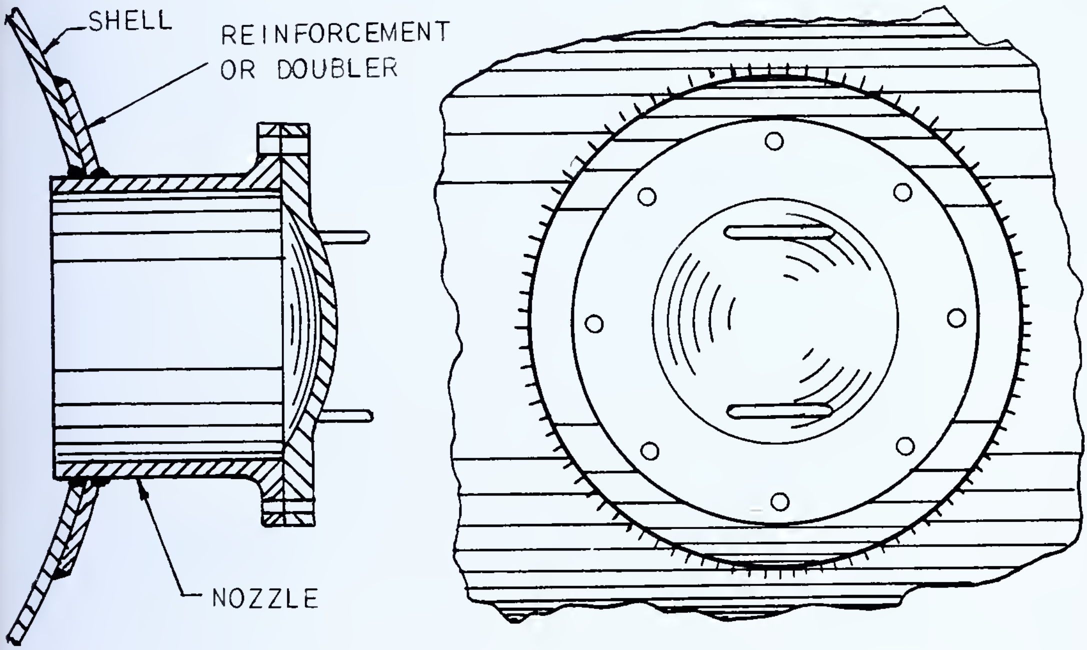


Fig. 387 — *Straight-Neck Manhole Nozzle*

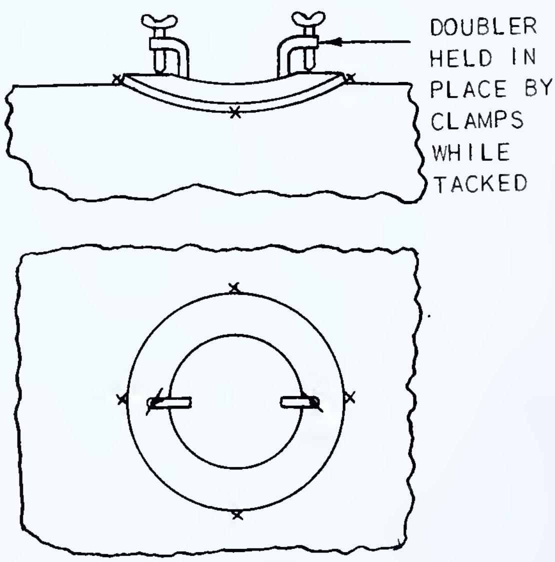


Fig. 388 — *Reinforcement Plate*

The opening into which the nozzle is to be welded is previously burned in the shell and chipped to a fit. The nozzle comes to the shop already made up and ready for installation.

A reinforcement plate is shown in Fig. 388. The plate is cut out and fitted in the shop. A hole is burned and chipped in the reinforcement plate to fit the nozzle with a clearance of ⅛″ diameter. When the plate is ready for installation, it is set on the shell according to the center lines which have been previously

* This typical example of Boiler Shop Practice may or may not be intended for marine use.

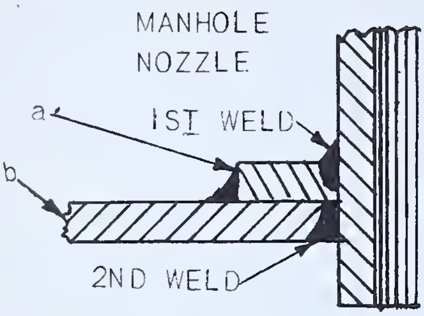


FIG. 389 — *Welding Locations for Manhole Nozzle*

scribed on the tank shell and on the reinforcement plate. The plate is then clamped down with C clamps and tack welded at various points.

The cross section in Fig. 389 indicates the locations at which the welding is done. The reinforcement plate is shown at *a*, and the tank shell is shown at *b*. Notice that the location for the first weld indicates a close fit between the nozzle and the reinforcement plate. The clearance all around is 1/16″. There is more space between the nozzle and the shell for the second weld. The edges of the reinforcement plate and the opening in the shell are chipped according to standard practice so indicated in Job Sheet No. 12, "*To Chip Welding Grooves.*" The C clamps are moved around the job as the tack welding proceeds in order to make sure that the plate is a tight fit in the shell all around.

PREPARING TO INSTALL THE NOZZLE

The nozzle must be located in the shell opening so that the face of the flange on the nozzle is level with the tank center lines and level with the outside wall of the tank longitudinally. The blueprint gives a dimension from the center line of the tank to the face of the nozzle flange. This distance must be maintained. Two angle clips are welded to the outside diameter of the nozzle wall as shown, and they hold the nozzle in the approximate position while it is being leveled.

The measurement for locating the angle clips is only approximate. The clips are welded on opposite center lines and not too close to the entering end of the nozzle. Care must be taken to have the nozzle extend rather too far into the tank than not far enough. It may be packed (shimmed) up, but it cannot be forced down. Fig. 390 at detail *a*.

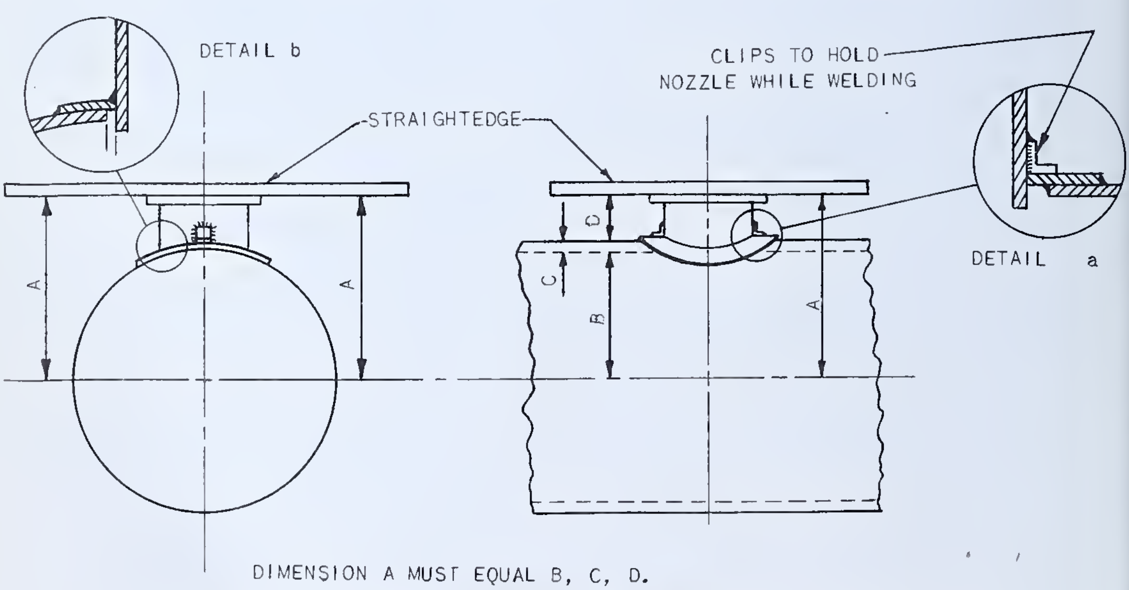


FIG. 390 — *Leveling and Welding the Manhole Nozzle in Place*

The nozzle is then located in the opening as shown in Fig. 390. Measurement *A* is taken from the blueprint. A straightedge is placed across the nozzle flange as shown, and the measurements are checked for accuracy. Shims are placed between the angle clips and the surface of the reinforcement plate to bring the face of the flange to the correct height above the center line of the tank. Small wooden wedges may be driven into the opening between the nozzle wall and the reinforcement plate to hold the flange face level with the side (horizontal) center line.

When the face of the nozzle flange is correctly leveled, it is tack welded all around. The job is now ready for the welders to finish.

Fitting and Installing a Flanged-Neck Manhole Nozzle

A flanged-neck manhole nozzle is shown in Fig. 391. There is no reinforcement plate used with this type nozzle, and the neck does not project inside the tank. The curved flange on the nozzle is centered and clamped to the shell curve. Use clamps in the same manner as shown in Fig. 371, Job Sheet No. 13.

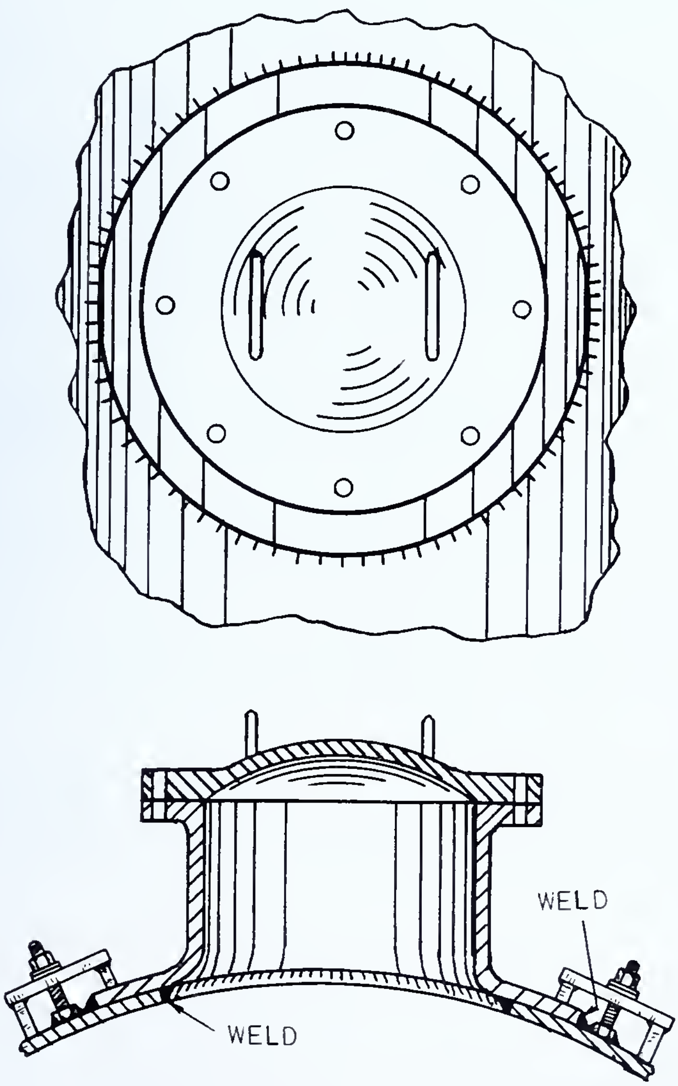


Fig. 391 — *Flanged-Neck Manhole Nozzle*

Manhole Covers

A dished manhole cover is shown in Fig. 387. This type of cover is secured in place with bolts and is generally used on a horizontal tank. A hinged manhole cover is used on a vertical tank as shown in Fig. 392.

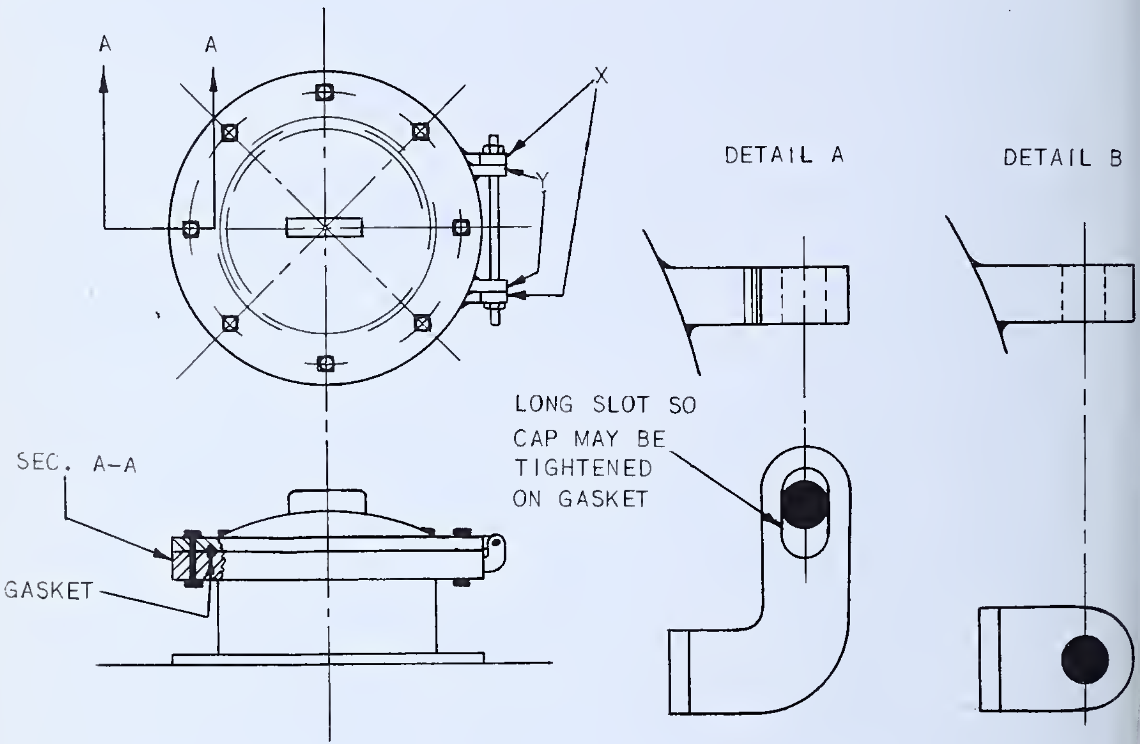


Fig. 392 — *Manhole Cover Hinged to a Vertical Tank*

After a manhole nozzle has been welded in place on a vertical tank, the hinges shown in Fig. 392 at detail *A* and detail *B* are welded in place. The direction in which the cover is to swing is given on the blueprint. An RTJ (ring-tight-joint) gasket is placed on the nozzle flange, and the cover is tightened down in place with a few bolts as shown at section *A-A*, Fig. 392. The hinge lugs and the hinge pin are assembled as shown at *x* and *y*.

Level the nozzle-neck flange in the same manner as was described in Fig. 390. Use shims under the flange, if necessary, to adjust it to the correct alignment. When it is correctly aligned, have it tack welded all around. The job is now ready for the welders to finish. Figure 391 shows the location of the welds inside and outside of the shell.

The assembly is held in place on the nozzle flange and on the cover by hand. Center lines on the nozzle flange are used to guide the hinge assembly into place on previously scribed lines. The hinge lugs are tack welded in place. The job is now ready for the welder to finish.

Installing Nozzles on a Dished Head

Nozzles are installed on dished heads of certain jobs. The nozzles are located, leveled, and welded as shown in Fig. 390. When checking the correct height of the nozzle flange from the side of the shell, always measure on the center lines marked *a*, *b*, and *c* in Fig. 393. The distances from the center line of the shell should be measured as shown at *x*, *y*, and *z*.

To install manhole nozzles or other similar nozzles use:

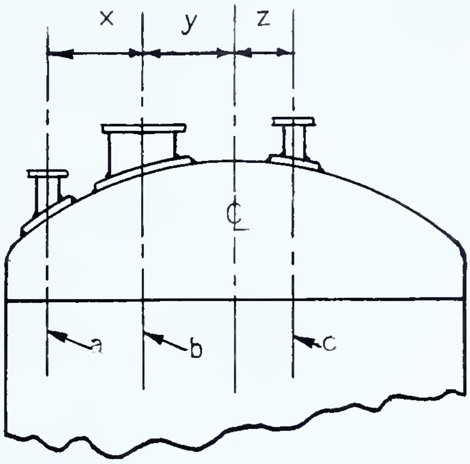


Fig. 393 — *Nozzles on a Dished Head*

Tools and Equipment

1. 6′ folding rule
2. C clamps
3. 8′ straightedge
4. Combination square
5. 1″ spud wrench
6. ¾″ spud wrench
7. Portable grinder
8. Ball-peen hammer

Materials

Soapstone
Two angle clips
Wooden wedges

To Install a Straight-Neck Manhole Nozzle

Procedure

1. Check the blueprint for the correct size and type of nozzle and reinforcement plate.
2. Secure correct nozzle and reinforcement plate from shop stores.
3. Scribe center lines on the outside of the neck of the manhole-nozzle.
4. Locate angle clips and tack weld to nozzle neck.
5. Place nozzle neck in shell opening and let it rest on angle clips.
6. Place straightedge across nozzle-neck flange, and level the flange longitudinally according to dimensions given on blueprint (as shown in Fig. 390).
   Use shims under angle clips to raise the nozzle neck to, and level at, the correct height.
7. Level the nozzle-neck flange with the side (horizontal) center lines.
   Use wooden wedges to hold it in a level position.
8. Tack weld the nozzle neck to the reinforcing plate at suitable intervals all around.

To Install Hinges for a Hinged Manhole Cover

Procedure

1. Check the blueprint for the correct size and detail of hinge lugs.
2. Lay out on the nozzle flange and the cover plate the correct location for the hinges.

3. Obtain the correct gasket for the job (see blueprint), and place it on the nozzl[e]
   neck flange.
4. Bolt the cover plate in place.
5. Assemble the hinge lugs on hinge bolt as shown in Fig. 392.
6. Hold the hinge-lug assembly in place, and tack weld.

TYPES OF NOZZLES

Types of nozzles similar to those described in the foregoing are illustrated i[n] Fig. 394.

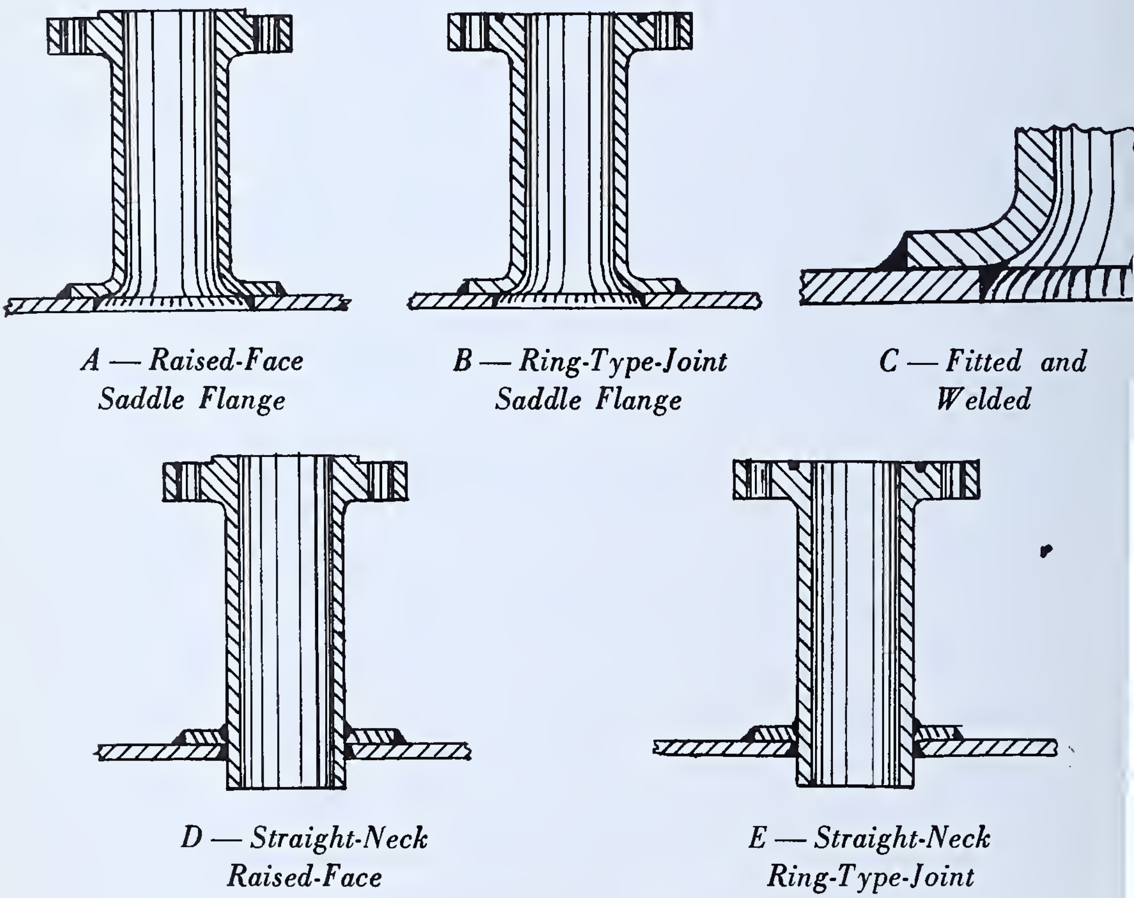


FIG. 394 — *Types of Nozzles*

These various nozzles are all welded to the shell. The method of fitting and attac[h]ing each nozzle is slightly different in some instances.

The nozzle shown at *A* is called a RAISED-FACE SADDLE FLANGE. The sa[d]dle is fitted to the shell and needs no reinforcement plate (doubler) because t[he] base of the nozzle is turned out to form a flange.

The nozzle shown at *B* is called a RING-TYPE-JOINT (RTJ) saddle flange. T[he] ring (groove) in the face of the flange is provided to allow the use of a ring gask[et]. The base of the nozzle is fitted and welded to the shell in the same way as nozzle .

The section shown at *C* is a detail of the fitted and welded nozzles *A* and *B*.

A straight-neck, raised-face nozzle is shown at *D*, and a straight-neck, ring-type-joint nozzle is shown at *E*. Nozzles *D* and *E* require a reinforcement plate (doubler) around the neck where they go through the shell.

QUESTIONS

1. **What is the purpose of a manhole in a tank?**
2. **What clearance is allowed between the nozzle neck and the edge of the reinforcement plate opening?**
3. **Explain the method used to fit the reinforcement plate to the shell.**
4. **State how the nozzle is held in the shell opening while it is being leveled to the blueprint dimensions.**
5. **What is meant by "side center line"?**
6. **Explain the meaning of "longitudinal leveling."**
7. **Why are hinges used on the manhole covers of some tanks?**
8. **Explain the reason for having the gasket in place when fitting the hinges to the manhole flange and cover.**

JOB SHEET NO. 17
TO FORM A CONE FRUSTUM ON A FLANGE PRESS*

General Information

A cone frustum cannot be rolled into shape in the manner described in Machi
Operation No. 1. The reason for this should be obvious. The cone frustum shown
Fig. 395 has been formed on the flange press, hammered to shape (aligned on t
base), and the seam welded. Note the ripples on the inside surface. These ripples a

Fig. 395 — *Frustum of a Cone*

the result of the forming operation which was performed on the press. Note the uniformity of the finished job.

The Blank

The blank plate shown in Fig. 396 is prepared by the layout man and burned off to the outline. It is ready to be bent on the press.

The radial lines on the blank are spaced at regular intervals, and the spaces can be divided into five equal groups.

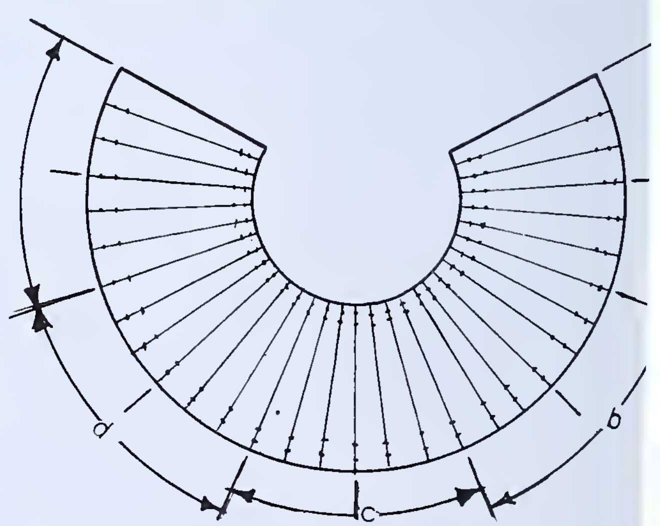


Fig. 396 — *Cone-Frustum Blank Marked for Bend*

* This typical example of Boiler Shop Practice is not intended for marine use.

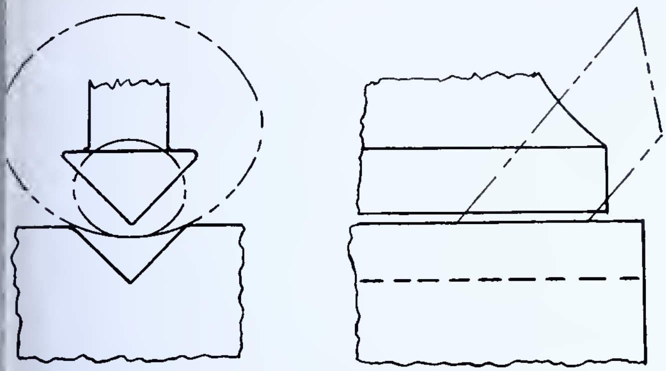


Fig. 397 — *Forming the Blank in the Press*

Forming the Blank

The flange press can be equipped with especially designed forming dies. The forming dies shown in Fig. 397 are vee-shaped so that the blank may be broken (bent) sharply. It is sometimes necessary to place shims in the hollow vee to produce a break (bend) of the proper angularity. As the blank is formed, the shape is changed gradually from flat to conical.

Making the First Breaks

Note the five lettered spaces in Fig. 396. The blank is placed on the lower die so that the location of the first dividing line is aligned with the ridge on the vee. The blank is then bent by the flatter plunger as it descends. The piece is then moved to bring the next dividing line into alignment on the vee, and the operation is continued. The job is shown in Fig. 398 after the piece has been bent on all four dividing lines. This bending process produces the five flats which are spaced off on the blanks lettered in Fig. 396 as *a, b, c, d,* and *e*.

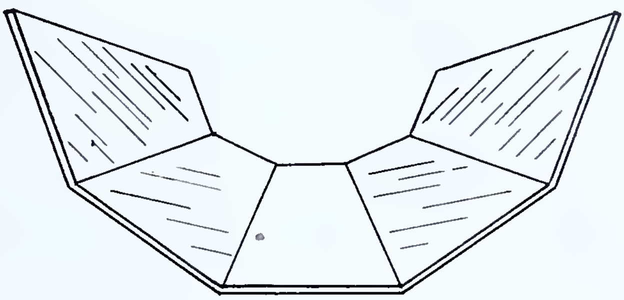


Fig. 398 — *The Cone Partially Formed*

Marking the Second Breaks

Subdivisions of the five spaces just treated are shown in Fig. 396. The short radial marks indicate the subdivisions. Repeat the bending operations with each of the subdivision lines aligned on the lower vee as before. This second pass will produce a secondary shape (shown in Fig. 399).

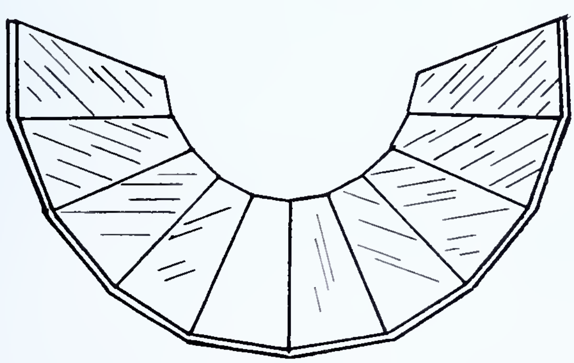


Fig. 399 — *The Cone Partially Formed After the Second Pass Through the Press*

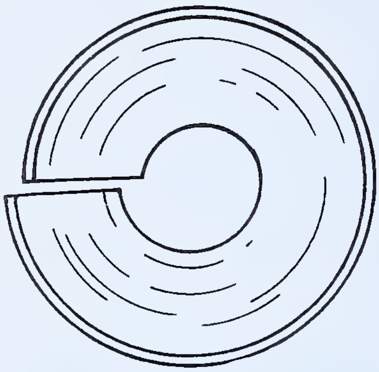


Fig. 400 — *The Finished Job Ready for Aligning the Seam*

Finishing the Bending

Other dividing lines are shown in Fig. 396. Contin the bending operations until each line has been align on the lower vee and the shape further broken dov The cone frustum is now approaching the shape shov in Fig. 400. Care must be taken not to bend the pie too far; if it is bent too far, it is difficult to reve the process. As the work approaches the finish shape, templates are used to check the curve at the t and bottom of the cone frustum.

The templates (or sweeps) shown in Fig. 401 a made according to the blueprint curve of the co frustum. They are used frequently to check the cu of the piece when the wo approaches the final stages bending. The holes in the en of the templates are used hang them up when they a not in use. The job is work back and forth between the d until the surface of the co frustum is regular and the sea meets evenly as shown in Fi 402. The job should be formed with enough "sprin to makes the seam come together "hard."

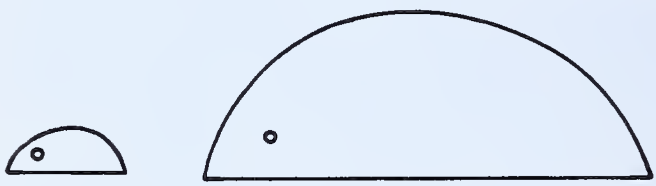


Fig. 401 — *Templates Used to Check Curve*

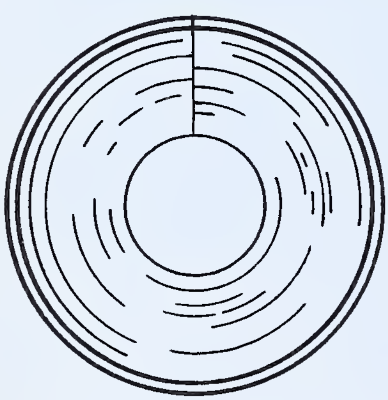


Fig. 402 — *Cone Frustum Finally Formed*

The seam is then tack welded. A groove is chipp between the tack welds, and the seam is welded l tween the tack welds. The chipping is then continu and the entire welding job is completed.

Aligning the Base of the Cone Frustum

After the welding has been completed, the job aligned on the base as shown in Fig. 403.

The cone frustum is placed on a level block a hammered until the base is in alignment with the blo and until the inside surface conforms to the templat This hammering operation is called "molding t surface."

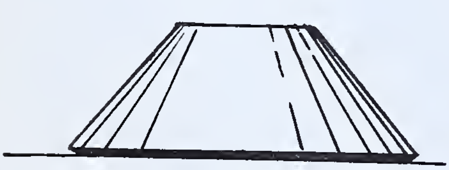


Fig. 403 — *Aligning the Base*

Tools and Equipment

1. 36″ straightedge
2. Rule
3. 8-lb. flange hammer
4. Air chipping hammer
5. Flat chisels
6. Gauge
7. 1¼″ open-end wrench
8. 1 large sweep (template)
9. 1 small sweep (template)
10. 1 plate dog
11. Male and female vee blocks
12. Air hose
13. Welding machine

Materials

Soapstone
Bolts
Clips
2 Plate straps
½″ x 3″ x 6″

The work involved in operating a flange press for the purpose of forming a cone frustum or other similar shape may be summarized as follows:

Procedure

1. Obtain the correct dies for the job and fasten them securely in proper position on the flange press.
2. Obtain from the layout bench the flange that is to be bent.
3. Determine by inspection, or by counting the spaces on the laid-out work, the correct location of the first bend which is to be made on the blank.
4. Align this bend location correctly on the lower vee die.
5. Hold the work securely, lay in position, and manipulate the control valve to cause the plow plunger to descend and make the bend.

   If the bend is not formed deep enough at the front or at the back of the blank, shims must be used in the upper die to produce the correct bend. Take care that the plunger is not allowed to descend too far.
6. Move the blank to the next predetermined position on the lower die and complete the operation.
7. Continue the bending operation until the blank has been passed through the die once.
8. Select the correct points at which the intermediate bends are to be made, and proceed to pass the work through the press as before.
9. Continue to select other intermediate bend locations and pass the work through the press once more.

   Check the curvature of the inside of the cone frustum as it begins to form, to make sure that it fits the template. Adjust the shims which regulate the amount of bend, if necessary.
10. Make any additional necessary bends at certain necessary locations to bring the seam of the cone frustum to a slightly overlapping position.

11. Check with the template once more to make sure that the curve of the inside uniform.
12. Remove the work from the press.
13. Spring the work so that the seam butts evenly.

    If necessary, tack weld angle clips to the outside surfaces and on opposite si of the seam so that the work can be pulled into alignment with a bolt.
14. Have the seam tack welded at 12″ intervals.
15. Chip the welding groove along the seam between the tack welds.
16. Have the seam welded from end to end.

To Align a Cone on a Base

1. Place the cone frustum on the leveling block with the base down.
2. Hammer the outer surface of the work with the flange hammer until it comes i alignment on the leveling block.

   Check frequently with the templates to insure a round shape.
3. Paint the proper piece mark and other notations on the outside of the co frustum.

QUESTIONS

1. **How is the blank of the cone frustum aligned on the dies to insure that the bend comes in the right location?**
2. **How many passes through the press are necessary to bend a cone frustum?**
3. **Explain the method of using shims to regulate the amount of bend in the plate.**
4. **Why at each bending operation is it necessary to regulate carefully the distance that the upper die descends?**
5. **State the reason for having the seam slightly overlapped when the bending operations are completed.**
6. **Explain the procedure for preparing the cone frustum for welding on the seam after the bending is completed.**
7. **What is the purpose of a template on this job?**
8. **How often are the templates used during the bending operation?**
9. **Explain the method of aligning the frustum base after the welding is completed.**
10. **What marks should be painted on the job when it is finished?**

JOB SHEET NO. 18
TO INSTALL STAY BOLTS AND FUSIBLE PLUGS

General Information

The combustion-chamber back head (Fig. 418) and the main back head inclose a water space. The generated steam pressure in the boiler has a tendency to cause these two heads to curve away from a perpendicular position. Continual variation in the boiler pressure with the accompanying in-and-out movement (flexing) of the head plates will cause fractures to develop and the fractures result in leaks. To prevent this flexing of the head plates, stay bolts are installed as shown in Fig. 404.

Types of Stay Bolts

Several types of stay bolts are used to serve various purposes. The type commonly used is shown in Fig. 404. Note the small hole in each end of the stay bolt. The purpose of the hole is explained as follows: Fractures develop in stay bolts, usually just inside of the plates at *a* in Fig. 404. When the fracture reaches a sufficient depth, the boiler pressure causes water and steam to run out of the small hole in the stay bolt as shown in Fig. 405.

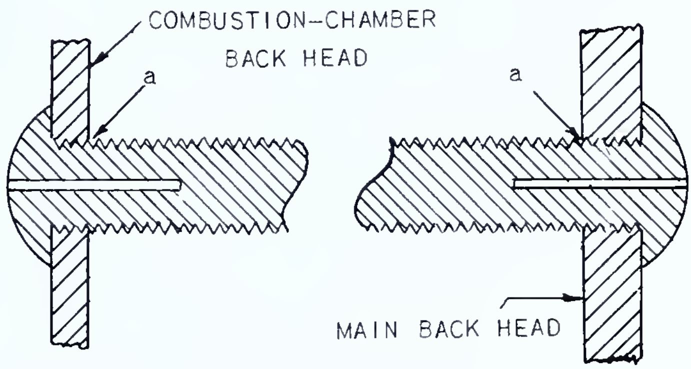


Fig. 404 — *Commonly Used Type of Stay Bolt*

Another type of stay bolt is shown in Fig. 406. This type of stay bolt has a telltale hole all the way through, and it is called a hollow stay bolt. Hollow stay bolts are installed in special locations. Figure 407 is a commonly used type of stay bolt.

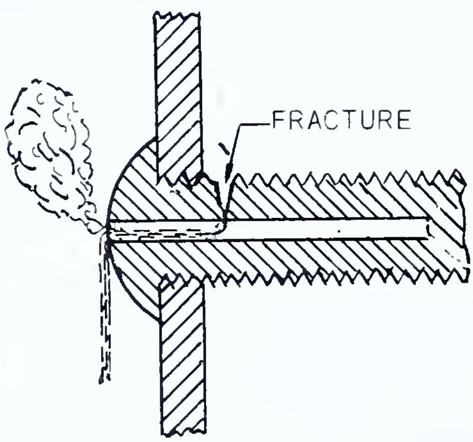


Fig. 405 — *Stay Bolt Fracture*

Stay Bolt Installation

Stay bolts are provided with a "neck" and extra threads at one end; a stay-bolt driver is applied at this end to install the stay bolt.

When the stay bolt has been screwed in to a sufficient distance, it is broken off or burned off at the "neck" as shown at *b* in Fig. 407. The projecting ends of the stay bolt are then turned over with a bobbing tool

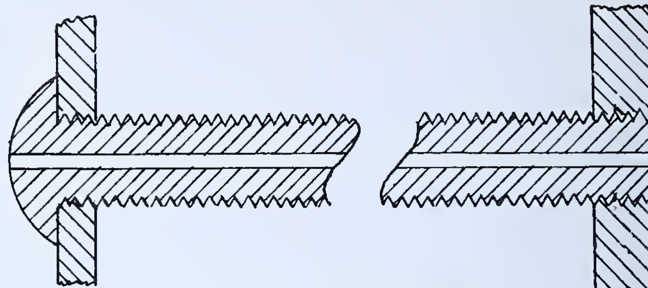


Fig. 406 — *Hollow Stay Bolt*

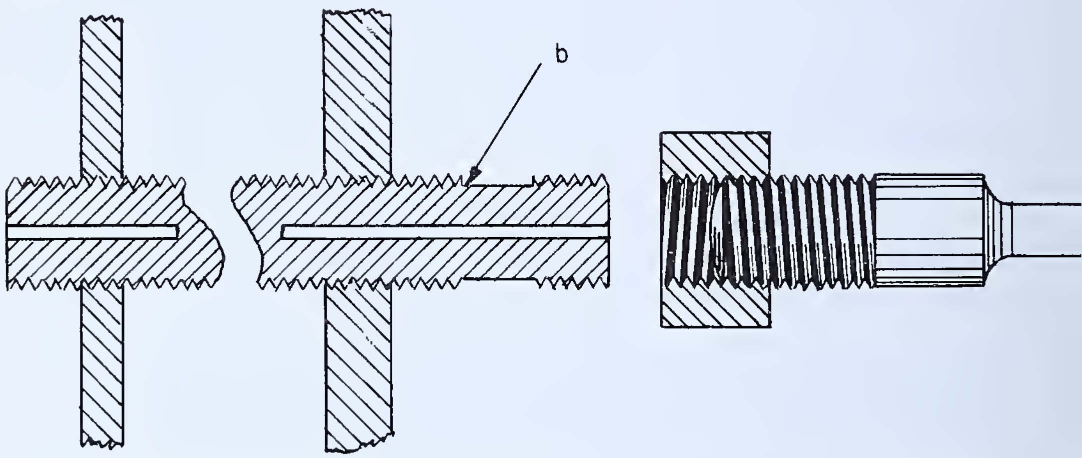


Fig. 407 — *Common Type of Stay Bolt Installed; Stay-bolt Driver*

and have the appearance of the one shown in Fig. 404. When the bobbing operation has been completed, the telltale hole is opened with a small drill in a pneumatic drilling machine. The bobbing tool shown in Fig. 408 is made from a wornout riveting tool. It is made short enough (for the thumb and fingers to grasp it) to prevent the loss of the tool while it is in use, and hold it firmly in the desired position during the bobbing operation.

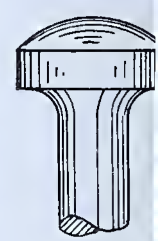


Fig. 408 – *Special Bobbing T*

Stay Bolts Secured in Position With Nuts

Another type of stay bolt is shown in Fig. 409. This stay bolt is inserted from the inside of the combustion chamber (firebox), and a nut is placed on both ends of the bolt. A special grommet (*a*) is placed on the end of the bolt which projects through the outside wall.

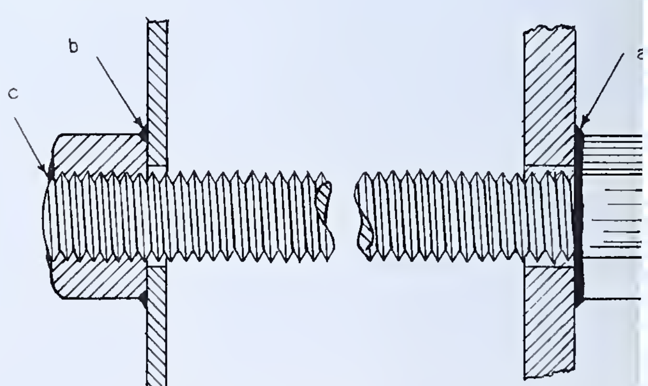


Fig. 409 — *Stay Bolt Installed with Nuts*

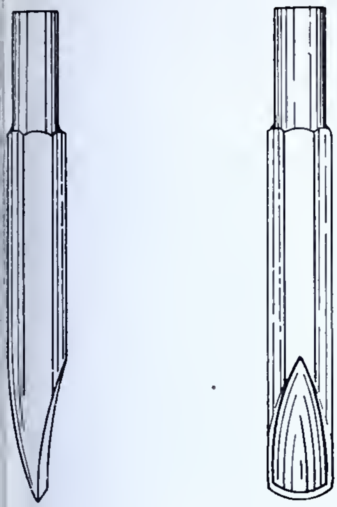


FIG. 410 — *Thumb Tool*

The nut is tightened with a box wrench and a six-pound maul. After the stay bolt has been inserted and the nut tightened on the outside, the nut on the inside is calked around the base and welded as shown at *b*. The joint between the nut and the bolt is then ringed with a thumb tool as shown at *c*. The thumb tool, mentioned above, is shown in Fig. 410. It will be noted that the nose end of the tool is so shaped that it will follow the joint between the nut and the end of the bolt. The gasket applied at *a*, the calking and welding at *b*, and the ringed joint at *c*, all contribute to make the job leakproof.

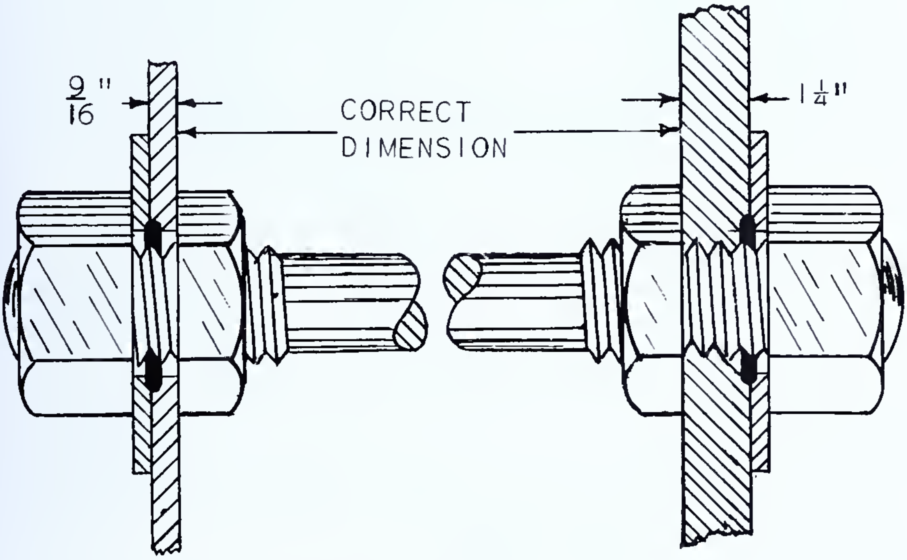


FIG. 411 — *Stay Rod Installed*

Main Stay Rod

Main stay rods are installed between the front and back heads of Scotch boilers and between the back tube sheet and the front head. The stay rod is shown in Fig. 411. It will be noted that half-nuts are used on the inside and whole nuts are used on the outside. The stay rod is inserted between the front and back heads, or between the back tube sheet and the front end. Half-nuts on the inside are drawn up until the correct dimension is obtained between the faces of the two half-nuts in Fig. 411. When the correct dimension has been obtained, apply red lead putty in the space between the bolt diameter and the boiler head and draw the nut up with a heavy wrench and a crane. Since these stay rods are very large (sometimes 3″ in diameter) it is necessary to use the crane to pull them up sufficiently tight. After the nut is pulled tightly in place, calk it to the plate with a heavy fuller. See Fig. 414.

Preparing to Install Stay Bolts

The holes in the boiler heads are tapped to suit the stay bolts as shown in Fig. 412. The stay bolt is threaded the entire length. The long tap is used to make sure that the threads on the stay bolt will pick up the threads in the opposite side smoothly and without strain. When there is insufficient room to run a full-length tap far enough through both heads and obtain a full thread, a tap that has been broken off at the lead end can be used to follow the thread through after the first head is tapped.

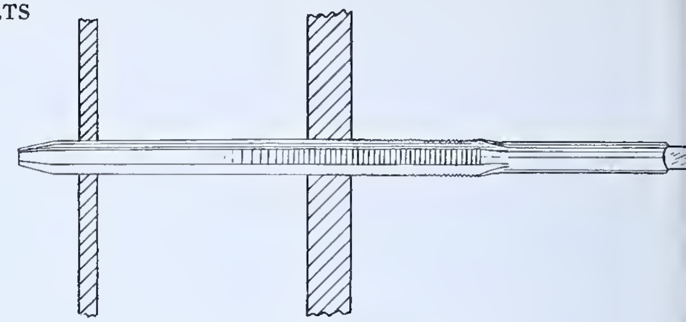


Fig. 412 — *Stay Bolt Tap*

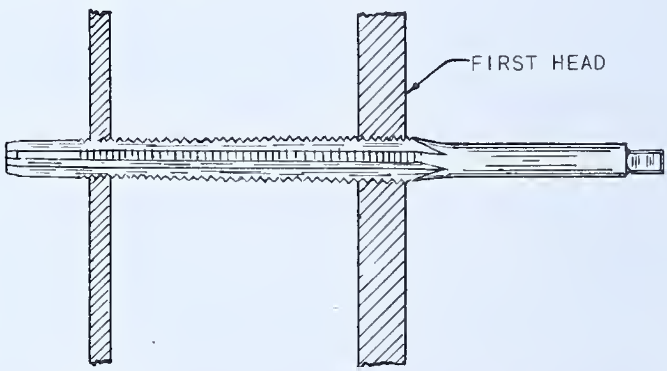


Fig. 413 — *Using a Broken Tap to Follow Through*

Fusible Plugs

If for any reason the water level in the boiler becomes too low, pressure would rise so quickly that extensive damage might be done before low-level water was noticed. To guard against this, the boilermaker inserts fusible plugs at convenient locations in the boiler where they will be in the path of hot gases and at the highest point in the boiler where the low-water level would first become evident. The centers of these fusible plugs are filled with a metal that melts at a temperature of 500 degrees. This temperature is sufficient to allow a working pressure of over 100 lbs. The function of the fusible plug is simple: when the temperature, for any reason, exceeds 500 degrees, the metal will melt, blow out, and warn the fireman or officer in charge that the water level is low.

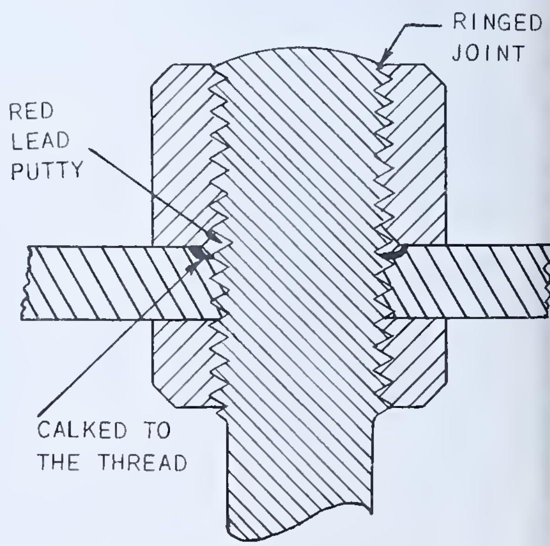


Fig. 414 — *Special Installation*

Typical examples of fusible plugs are shown in Figs. 415 and 416.

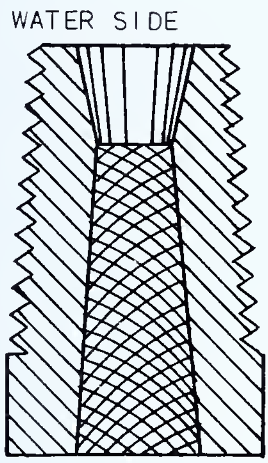


FIG. 415 — *Water Side*

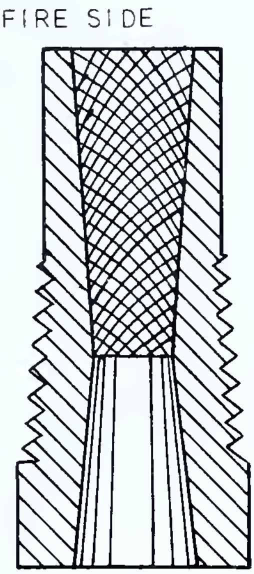


FIG. 416 — *Fire Side*

Figure 415 illustrates the type of plug which is used in the water side of the boiler, and Fig. 416 illustrates the type of plug which is used in the fire side of the boiler.

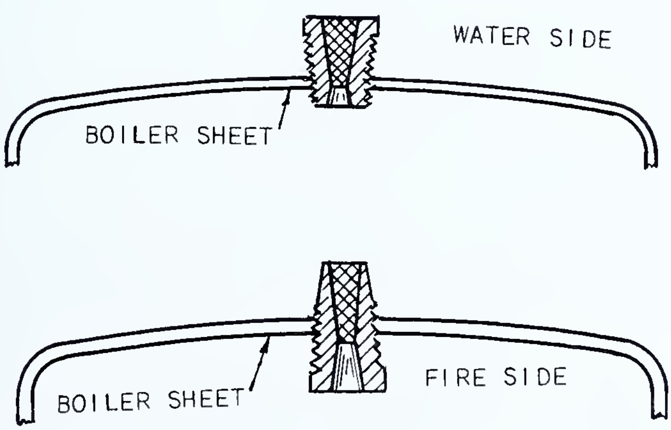


FIG. 417 — *Fusible Plugs*

The application of both types of fusible plugs is shown in Fig. 417.

Tools and Equipment

1. 6′ folding rule
2. Portable electric light
3. Pneumatic chipping hammer
4. Side-cutting chisels
5. Cape chisels
6. Gouge chisels
7. Center punch
8. Air hose
9. No. 3 pneumatic drilling machine
10. Chuck sleeve
11. Drills to suit bolt sizes
12. 3/16″ drills
13. 1¾ lb. ball-peen hammer
14. No. 3 tapping machine
15. Square socket to suit tap
16. Stay bolt driver
17. Calking tools
18. Bobbing tools
19. Pneumatic rest machine
20. Pipe wrench
21. No. 60 riveting hammer
22. 15 lb. short-handled sledge
23. 1″ standard pipe tap
24. Pipe tap wrench
25. Straight socket wrench
26. 10-thread stay bolt tap (for foreign boilers)
27. 12-thread stay bolt tap (for domestic boilers)

Materials

Cutting oil
Stay bolts
Fusible plugs

The work involved in installing commonly used stay bolts may be summarized as follows:

Procedure

1. Inspect the blueprint to determine the size of stay bolt tap required to tap the holes for the stay bolts.
2. Tap the holes according to the blueprint specifications.
3. Obtain the correct length of stay bolt.

   Allow ¼″ on each side of the sheet for riveting plugs for a neck and a head. See Fig. 407. If the stay bolt is of a nut type, allow enough length on each side of the boiler sheet to take a full nut.
4. Drill telltale holes in both ends of the bolt deep enough so that the bottom of the hole will come ½″ inside the water side of the sheet.
5. Install the stay bolt through both sheets as far as possible by hand; then use a stay-bolt driver, Fig. 407, to screw the stay bolt to the correct distance into the job.
6. Burn off the driving end of the stay bolt.
7. Calk the stay bolt on both sides whether it is to be tightened with nuts (as in Fig. 411) or headed over and riveted (as shown in Fig. 406).
8. Rivet the stay bolt over.

   For stay bolts up to 1½″ diameter, the bolt is "bucked up" with a 12-lb. sledge and riveted with a No. 60 riveting hammer. For stay bolts over 1½″ in diameter, use a No. 90 riveting hammer.

9. Finish off the job with a special bobbing tool (Fig. 408) in the riveting hammer.
   a. Upset the center of the stay bolt first, then work towards the outside diameter, turning the ends over close to the plate. Keep the tool away from the plate. Do not allow it to strike.
   b. Open the telltale hole with a 3/16″ drill in a pneumatic drilling machine.

Installing Special Stay Bolt With Nuts

1. Calk the stay bolt on both sides. Apply red-lead putty and a special grommet over the end of the stay bolt on the outside.
2. Install the nut, run it on by hand, and tighten it up with a box wrench and a 6-lb. maul.
3. Apply red-lead putty to the front side. Install the nuts and tighten up with a box wrench and a 6-lb. maul.
4. Ring the joint between the nut and the bolt with the thumb tool.
5. Calk the nut to the plate with a heavy fuller.

QUESTIONS

1. For what purpose are stay bolts used in marine boilers?
2. Describe an ordinary stay bolt.
3. Describe a through stay and a fore-and-aft stay.
4. State the locations of each of these stays in a Scotch boiler.
5. Describe a hollow stay bolt.
6. How far beyond the water side of the plates should the telltale hole be drilled in a stay bolt?
7. What causes stay bolts to fracture?
8. What is the indication of a fractured stay bolt?
9. Describe the correct procedure to follow to remove a stay bolt.
10. Explain the procedure for replacing one stay bolt.
11. What type stay bolt has the ends riveted over?
12. Do all boiler stay bolts have the same pitch of thread?
13. What is the correct procedure for removing a fore-and-aft stay?
14. What part of a fore-and-aft stay is bobbed and calked?
15. Where are fusible plugs located in a Scotch boiler?
16. Name the type and grade of stock from which fusible plugs are made.
17. How far should the stay-bolt ends project through the plates to afford enough stock for a well-riveted head?

JOB SHEET NO. 19
TO INSTALL SCOTCH-BOILER STAY TUBES AND GIRDER STAYS

General Information

A Scotch boiler is constructed of metal (boiler plate) shells, headers, and tubes. Like any type of marine boiler the Scotch boiler must be built to withstand water pressure and high steam pressure. If the boiler is not well constructed, the joints will leak, the boiler walls will buckle, and as a result, difficulty will be experienced in maintaining boiler pressure.

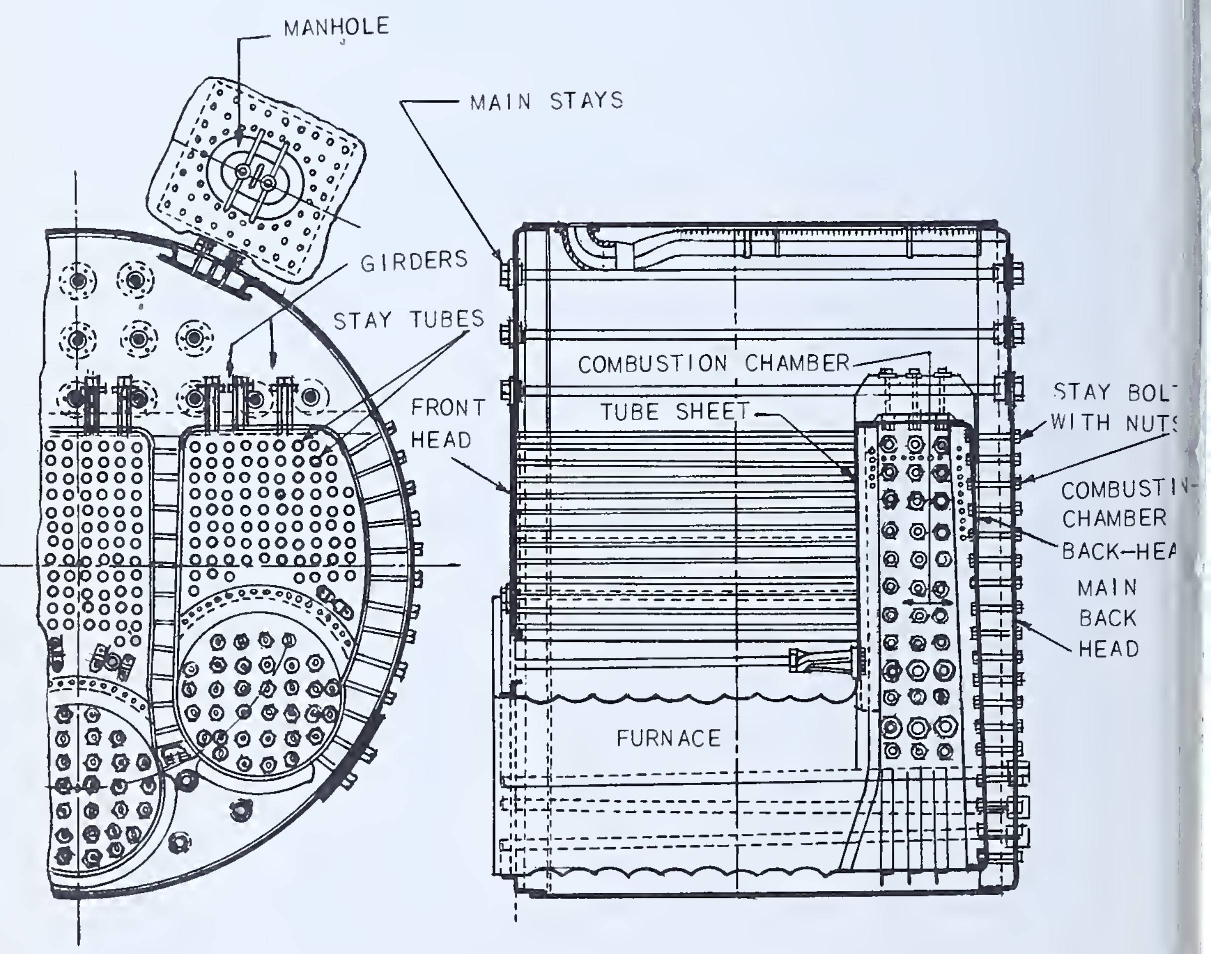


Fig. 418 — *Scotch Boiler Construction*

Typical Scotch boiler construction is shown in Fig. 418. Note the location of the firebox, the stay tubes, the stay bolts, the plain tubes, the back head, the front head, and other details. Many authorities require that boilers with a high working pressure should be braced so that very little stress will be placed on the plain boiler tubes, which are expanded into place. The bracing is accomplished by the use of stay tubes. Stay tubes act as end-to-end stays. They are long, hollow tubes which are threaded on the ends and screwed into the heads.

Installing a Stay Tube

A stay tube is shown in Fig. 419. Note that one end of the stay tube is smaller than the opposite end.

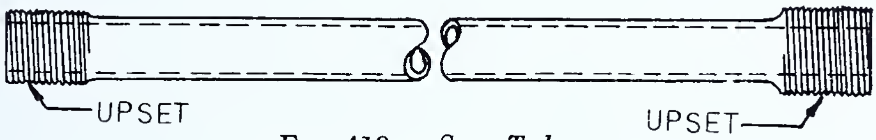


Fig. 419 — *Stay Tube*

The reason one end is smaller than the other is clearly shown in Fig. 420. The smaller end passes readily through hole *a*. The length of the stay tube is so calculated that the threads on the smaller end will engage the threads in hole *b* before the threads on the larger end can engage the threads in hole *a*.

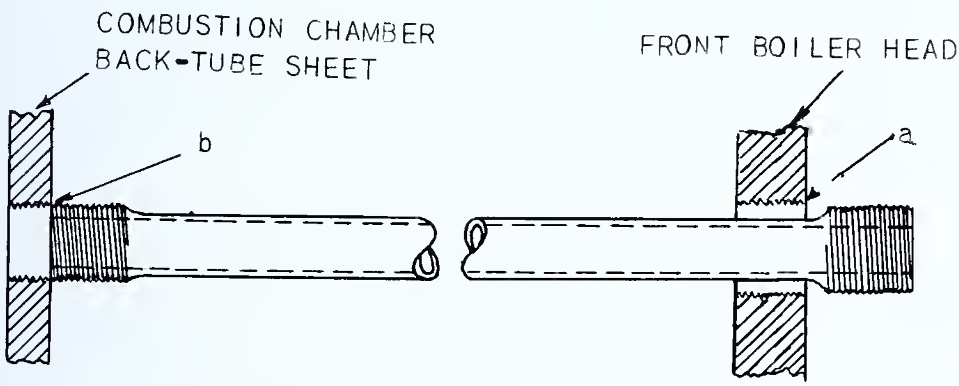


Fig. 420 — *Front Head and Back Head with the Stay Tube About to be Screwed in Place*

The holes in the front and back heads are tapped with the stay-tube tap shown in Fig. 421. The tap is so constructed that the tap enters and begins to cut a thread in the smaller hole first. The pilot bushings are adjusted on the tap shank to hold the tap true at either end while the opposite end is threading a hole.

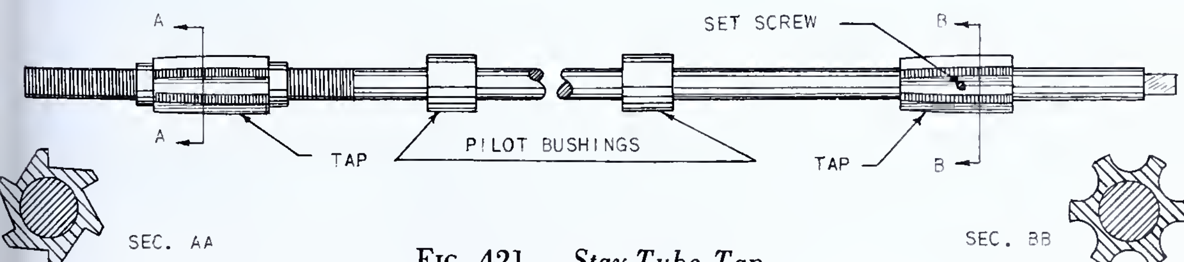


Fig. 421 — *Stay-Tube Tap*

The method of adjusting the bushings while tapping the holes is shown in Figs. 422 and 423.

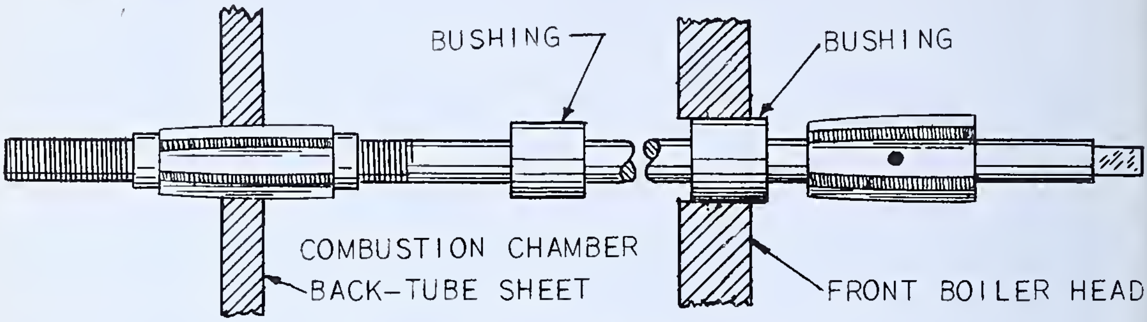


FIG. 422 — *Tapping the Small Hole*

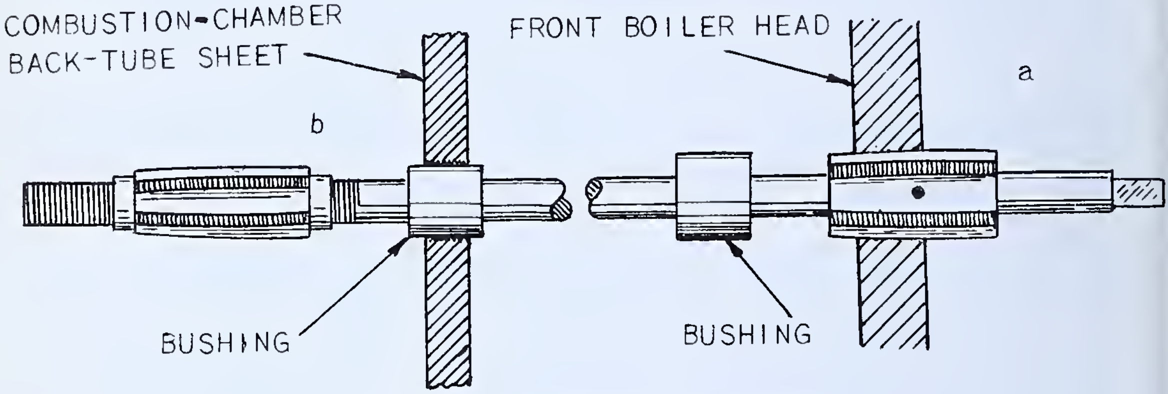


FIG. 423 — *Tapping the Large Hole*

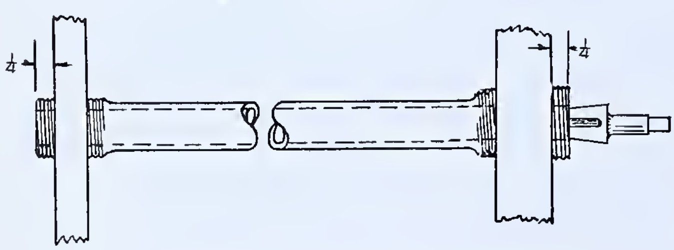


FIG. 424 — *Turning the Stay Tube into Place*

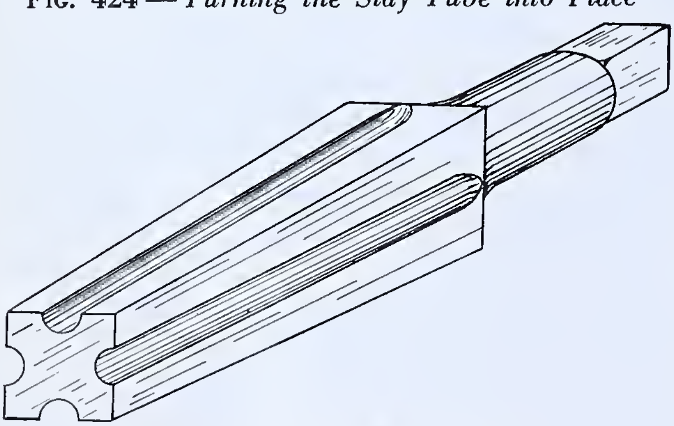


FIG. 425 — *Stay-Tube Inserter*

After the holes in the heads are tapped, the stay tubes are screwed into place. The stay-tube inserter shown in Fig. 425 is used to turn the stay tubes into the heads (Fig. 424).

The inserter is pushed into the hole at the larger end of the stay tube; a pneumatic driver is applied to the square on the end of the inserter shank, and the tube is turned into the threaded holes. The length of the stay tube has been calculated to allow it to project about ¼″ beyond the surfaces of the heads at both ends. The operation of turning the stay tube into place is shown in Fig. 424.

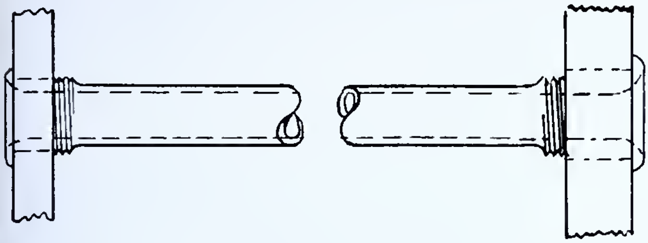


Fig. 426 — *Stay Tube Expanded, Flared, Calked and Beaded*

When the stay tube has been screwed into place, the ends are expanded (rolled), calked, flared, and the projecting ends are beaded as shown in Fig. 426.

Installing Girder Stays

The top of the combustion chamber (firebox) is usually supported by girder stays as shown in Fig. 427.

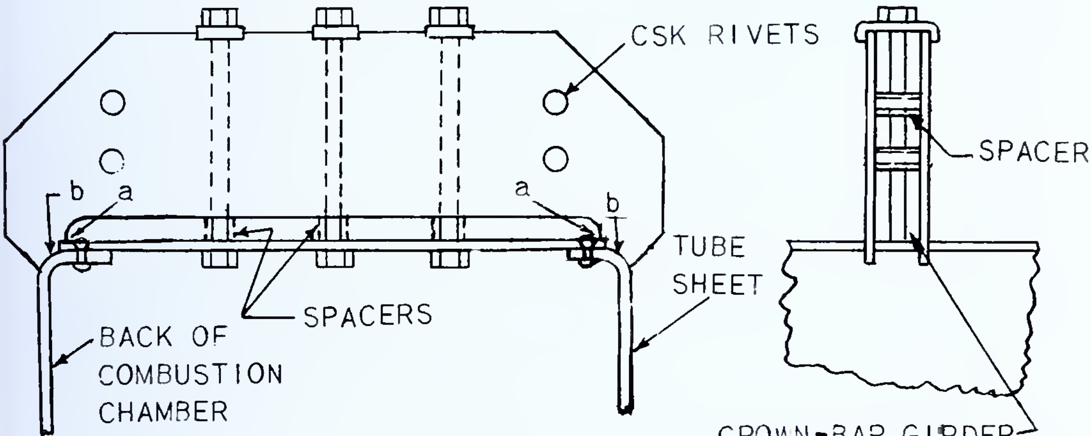


Fig. 427 — *Girder Stays*

Girder stays are sometimes called crown-bar girders. Each girder consists of two steel plates of the same shape and thickness set side by side and held apart at a fixed distance by thimbles (pipe spacers) through which pass countersunk-head rivets that hold the plates together.

This built-up girder is placed on top of the combustion chamber crown sheet. Its ends rest on the upper ends of the back-tube sheet and combustion chamber head. Crown bolts that are threaded on both ends (the end of the crown sheet is threaded to an extra-tight fit) are screwed into the holes in the crown sheet. The bolts pass between the girder plates, and a flanged washer is placed over the upper edges of the plates and over the bolts to prevent spreading of the plates.

Thimbles are placed between the crown sheet and the bottom edge of the girder plates to prevent buckling of the crown sheet when the nuts are tightened down on the top of the flanged washer. This arrangement of thimbles, bolts, and flanged washers makes the job rigid and keeps the crown sheet level.

The pressure on the crown sheet is transmitted to the girders by means of the thimbles and bolts. The girders rest on the back-tube sheet and the back's combustion chamber head and carry the entire load. Several of these girders are spaced at uniform intervals across the top of the combustion chamber crown sheet.

The work involved in installing stay tubes may be summarized as follows:

Tools and Equipment

1. Adjustable stay-tube tap (12-thread)
2. Pneumatic reversible wrench (knock-knock)
3. Pneumatic chipping hammer
4. Two square-chuck sockets
5. Tube inserter
6. Set of thread gauges for tubes (12-pitch)
7. Air hose
8. A large platform and trestles
9. $1\frac{1}{2}$-lb. ball-peen hammer
10. Electric light
11. Rigging to hold machine
12. Special calking tool
13. Special flaring tool
14. Special beading tool
15. Set of 2 sizes of tube expanders
16. Oil can
17. Marking brush
18. Straightedge

Materials

White lead
Cutting oil
Stay tubes

Procedure

1. Inspect the blueprint to find the correct size of stay-tube taps for the job.
2. Insert the stay-tube tap from the larger-hole side and prepare to tap the smaller hole.

   Adjust the large bushing on the tap body to center the tap shank in the larger hole as shown in Fig. 422.
3. Apply the pneumatic driver to the square end of the tap and tap the hole.
4. Adjust the small bushing on the tap body inside of the smaller tapped hole and remove the large bushing from the larger hole.
5. Insert the tap in the larger hole and proceed to tap it.
6. Remove the tap from the job.
7. Inspect the blueprint to find the correct length and size of stay tube which is to be used.
8. Insert the smaller threaded end through the large hole and "start" to screw it into the smaller hole.
9. Place the stay-tube inserter inside of the stay tube at the larger threaded end.
10. Apply the pneumatic driver at the square shank of the inserter and turn the stay tube into place.

    The stay tube is turned into place until it projects outside of the plates about $\frac{1}{4}''$ at each end.
11. Remove the pneumatic driver and the inserter.
12. Expand the stay-tube ends.
13. Calk the stay-tube ends.

14. Flare the stay-tube ends.
15. Bead the stay-tube ends.

    These four preceding operations are shown in Fig. 426.
16. Proceed in the same manner through Steps 1 to 14 until all the stay tubes are installed.

The work involved in installing crown-bar girder stays may be summarized as follows:

Tools and Equipment

1. Special 12-thread tap and lever
2. Stud driver
3. $1\frac{1}{2}''$ box wrench
4. Set hammer
5. 12-pound sledge
6. Pneumatic chipping hammer
7. Chipping chisels
8. 18″ half-round file
9. Special calking tool
10. 8″ x 12″ steel square
11. Straightedge

Materials

Crown-bar girders
Spacer pipe
Crown bolts
Flanged washers
Half nuts
Full nuts
Rule
Red-lead putty

Procedure

1. Inspect the blueprint to find the location of the girder stays on top of the crown sheet.
2. Obtain the girder stays, thimbles, crown bolts, nuts, and flanged washers according to blueprint specifications.
3. Insert the crown bolts which hold the girder to the crown sheet.

   Use a stud driver and insert the extra-tight threaded end of the crown bolts into the tapped holes previously prepared in the crown sheet.
4. Put a thimble over each crown bolt to rest on the crown sheet.
5. Place one set of girders over the crown bolts to rest on the upper ends of the back-tube sheet and the combustion chamber head.
6. Fit the corners of the girder plates.

   The bearing ends of the girder plates must be fitted snugly on the crown sheet and on the ends of the stay-tube sheet as shown in Fig. 427 at *a* and *b*. The fitting can be done by chipping and filing, or the plate can be heated and the ends seated with a set hammer and a maul.
7. Place the flanged washers over the crown bolts.
8. Place the nuts on the crown bolts and draw down tightly.

QUESTIONS

1. Describe stay tubes and give reasons for using them.
2. What is the difference between a stay tube and a plain tube?
3. How are stay tubes installed?
4. Why are the ends of the same stay tube turned to different diameters?
5. Describe the procedure for calking stay tubes.
6. Does standard practice demand all stay tubes to be flared and beaded?
7. Why are pilot bushings used on stay tube taps?
8. What is the pitch of the thread for a domestic boiler stay tube tap?
9. How far should the stay tube project through the combustion chamber tube sheet?
10. What is the procedure if the stay tube projects too far beyond the front end of the boiler?
11. How far should the rolls go beyond the head on the inside when rolling tubes?
12. What is the purpose of the stay-tube inserter?
13. Describe a crown-bar girder.
14. How many plates make up one crown-bar girder?
15. Describe the methods of fastening crown-bar girder plates together.
16. How tightly should crown-bar girders be fitted?
17. What is the purpose of a washer on top of crown-bar girders?
18. Why are thimbles used between plates that make up the crown-bar girders?
19. What is the purpose of the thimbles between the crown-sheet and the crown-bar girders?
20. How should the crown-bar girders fit the knuckle of the back combustion-chamber top and the combustion-chamber backhead top?

JOB SHEET NO. 20
TO PREPARE WORK BY CHIPPING AND GRINDING

General Information

After cylindrical tanks or shells have been welded, the longitudinal and girth seams must be chipped and ground to insure a smooth surface and to eliminate dross and surplus metal so that an x-ray test can be made.

The mechanic shown in Fig. 428 is chipping the longitudinal seam along one side of a shell section of a cylindrical tank. This section will eventually become part of the long cylindrical tank that is shown in Fig. 430. The ring flange has been fitted and welded to the shell in Fig. 430. A mechanic is shown grinding the girth seam on the inside of the cylinder.

The appearance of a welded seam before chipping is shown in Fig. 429. Note that the welds on opposite sides of the shell have been interwelded at the center, making the weld a part of the shell. The x-ray test will reveal any "pockets," inclusions, or other defects in the weld.

Fig. 428 — *Tank Section — Chipping the Longitudinal Seam*

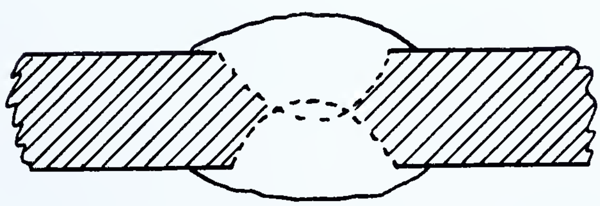


Fig. 429 — *Appearance of Welded Seam Before Chipping*

Fig. 430 — *The Ring is Attached to the Shell*

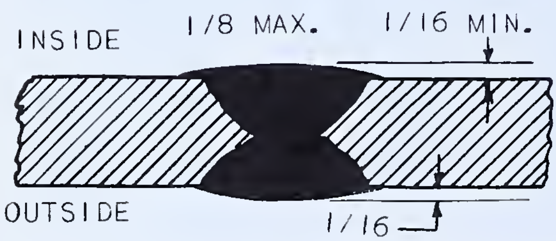


Fig. 431 — *Appearance of Welded Seam after Chipping and Grinding*

Before the weld is x-ray tested the chipper cleans it off to the limits shown in Fig. 431. Note the maximum and minimum limits of the rounded surfaces of the welds.

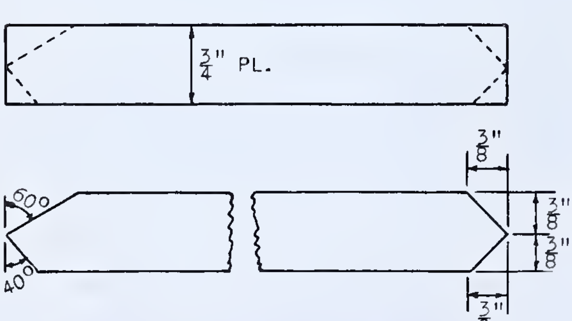


Fig. 432 — *Plate Cross Section*

Chipping Plates to a Fit

The chipping job shown in Fig. 433 is a curved plate and the edge on the outside of the curve must be chipped on a bevel to fit against another part of the fabricated assembly.

Fig. 433 — *Chipping a Bevel on a Plate*

A cross section of the end of the plate is shown in Fig. 432. When the plate has been chipped to a bevel on one edge it is turned over to have the other edges chipped. A sheet-iron or sheet-tin gauge is used to check the bevel as the chipping progresses. The bevel is given in either degrees or inches. The work is held to the heavy iron

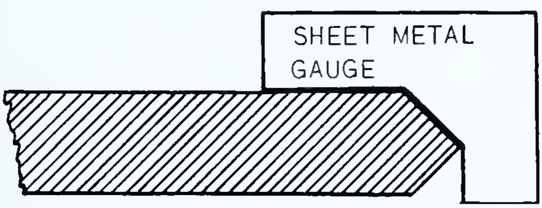


Fig. 434 — *Gauging the Edge*

slab by means of plate dogs which are wedged tightly into the square holes in the table slab. The maul shown on the slab is used to drive the plate dogs into the holes. With one end of the bar resting on the work the wedge effect clamps it securely.

Chipping to Good Metal

The ends of two plates have been welded together (Fig. 435) and the job has been turned over to be "backwelded." A welding job is not strong nor sound unless the welding can be done on clean metal. The mechanic in Fig. 435 is chipping to clean metal preparatory for the welding job which is to follow.

Job Sheet No. 12, "To Chip Welding Grooves," Fig. 344, shows the type of weld that is to be made on the ends of the plates shown in Fig. 435.

Fig. 435 — *Chipping to Clean Metal*

Safety

Note the position of the chipper. He is standing in a rather uncomfortable position to do this job. If he were to kneel down there would be danger of cutting the knees or legs on the steel chips and cuttings scattered about the floor. This job is too large to be placed on a table slab and the weight of the plates is sufficient to hold them in position while the chipping is done.

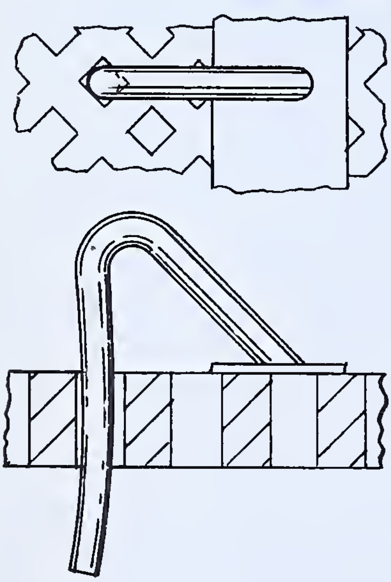


Fig. 436 — *Plate Dog in Position*

Work should be placed on a table slab whenever it it possible to do so. It is safer and the job can be done more speedily and accurately.

Note the chipping chisels in the pail on the corner of the slab.

Setting a Plate Dog

Always set a plate dog so that the dog will be in a corner of a square hole as shown in Fig. 436. When the dog is in this position it will grip better and hold more securely.

Two ring flanges are shown in Fig. 437. The inside edge of the ring is chipped to fit a nozzle and also the bevel provides a clean-metal surface to which the nozzle can be welded.

Before the inside bevel is chipped as in Fig. 437 the most of the metal is removed by burning. The blueprint is marked to indicate the burning line as shown in Fig. 438. After the burning is completed the edge is chipped as indicated. A template or sheet metal gauge is used as indicated in Fig. 434.

Fig. 437 — *Chipping a Bevel on the Inside of a Ring Flange*

Cutting-Chisel Economics

Note in Fig. 433 the pail filled with tools. Keep these tools in a pail or similar container. Never get more tools out of the tool crib than are absolutely necessary for the job. To do so will only tie up the tools in one location and deprive someone from getting necessary tools for some other job. Lost tools or hidden tools only serve to increase the expense of keeping an adequate supply of tools available.

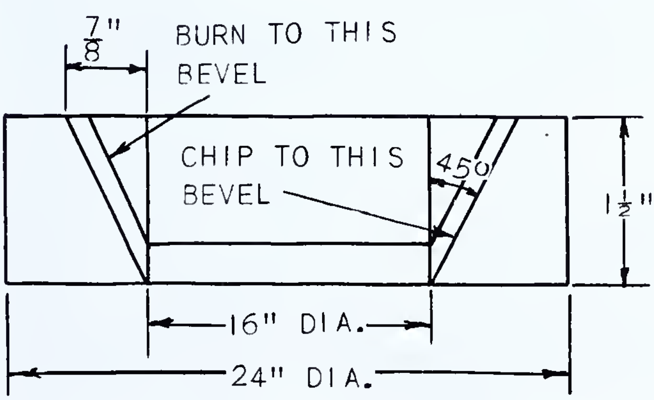


Fig. 438 — *Blueprint Markings*

Tools and Equipment

There are available chipping chisels for every job. Never use a dull chisel. See that the pneumatic chipping hammer is in good working condition. Avoid dragging the air hose over hot plates.

The following general procedure is followed when chipping and grinding.

Procedure

1. Be sure to understand clearly what type and size section of work must be chipped or ground.
2. Select the correct chisel or grinding wheel for the job.
3. Make sure the grinder or chipping hammer is in good working condition.
4. Secure the work to the slab (if the job is to be chipped or ground on a slab).
5. Place and secure the work in the correct working position (if the job is to be done on the floor as in Fig. 428).
6. Chip or grind the work according to instructions.

QUESTIONS

1. **What operations are required to prepare welded seams for X-ray?**
2. **How high should the reinforcement of weld be: a. On the inside seams? b. On the outside seams?**
3. **What is an under cut?**
4. **How is this defect repaired?**
5. **In Fig. 437 note that some of the material has been burnt away. How does this affect the chipper's job?**
6. **What is used to check the proper bevels?**
7. **What is back chipping?**
8. **Why do we back-chip single-beveled and double-beveled or V-groove seams that are hand-welded?**
9. **How are jobs fastened to the slab while they are chipped?**
10. **In what order should a chipper keep his tools?**
11. **How many chipping chisels should a chipper have on the job?**
12. **What protection does the company give for the protection of the two important organs of the body?**
13. **Should a chipper leave any unfinished chipping burrs on his work when he leaves his job? Why or why not?**
14. **What kind of gloves give your hands the best protection from cuts?**
15. **Figures 433, 435, and 437 show three men chipping on different jobs. Compare the good and bad features of each job.**
16. **What would you do if you had a leaky hose?**

JOB SHEET NO. 21
TO BURN STEEL PLATES TO SHAPE

General Information

After steel plates have been laid out to the required shape as shown on the blueprint they must be cut to the line, bevels must be formed on certain portions of the plate, radii must be worked on plate corners, and in some cases circular or square holes must be cut in several locations.

Many of these shapes would be difficult to machine-cut because the plates are heavy and placing them on a machine table takes time. Many special tools would be required which would involve considerable expense. The use of a burning torch eliminates these objectionable features.

Burning in the Boiler Shop

Some work is burned while it is lying on the boilershop floor; openings are burned in the sides of tanks in close quarters; other burning is done on the top and on the under side of large tanks without moving the tank; many burning jobs are done on a table or special fixture.

The Cutting Torch

In that the torch which is used burns the metal along the layout lines and leaves a narrow opening like a sawcut the term "cutting torch" is commonly used.

The operator in Fig. 439 is shown at work burning the end of a steel plate to a line. This is a hand-burning job and the accuracy of the cut depends upon the skill of the operator.

Note that the tip of the torch is at a right angle with the work. The operator moves the torch along fast enough to burn continuously new metal and so prevents the waste of gas and oxygen. When the torch is kept moving at the correct speed the burned end of the plate will be smooth and almost as clean as though it had been cut with a machine tool.

Fig. 439 — *Free-hand Burning to a Line*

Acetylene and Oxygen

There are two connections on cutting torches (Fig. 102) to which the hose lines are attached. One hose line (red) carries acetylene gas; the other hose line (green) carries oxygen. These hose lines are equipped with special couplings which are attached to manifolds. The manifolds are located at convenient places throughout the boiler shop.

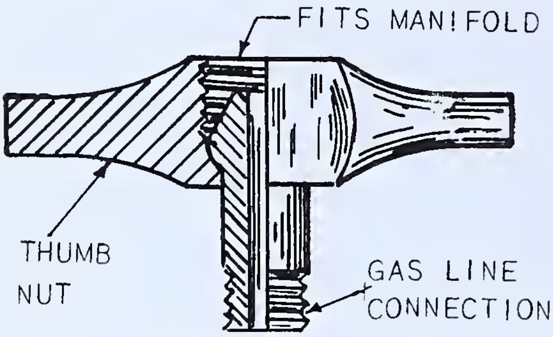


Fig. 440 — *Adapter*

Each operator obtains from the tool crib an adapter (Fig. 440) which is charged to him on his clock card. Before he can check out at the end of the day he must return the adapter to the tool crib in order to receive his clock card. This procedure is a safety precaution. The adapter is attached to the gas manifold by means of the thumb nut. The gas hose is then attached to the end of the adapter. This process has to be reversed before the operator can return the adapter to the tool crib and receive his clock card.

If some precaution such as this were not taken the operator could leave the torch lying on the job, the valve *c* in Fig. 102 could be accidently opened, and gas would escape. Since a spark or an open flame will ignite this gas instantaneously it is obvious that the escape of gas must be prevented.

After the operator connects the hose lines to the cutting torch at one end and to the manifold at the other end, the manifold valve is opened and the burner is ready to go to work.

Caution: Make sure the valves *a* and *b*, shown in Fig. 102, are closed before opening the manifold valve. If the operator gives strict attention to his work and follows the instructions of the foreman or leader he will not be injured or cause injuries to others.

Cutting-Torch Tips

Since plates of various thicknesses must be cut (burned) it follows that various sized tips must be used. The tips are interchangeable. The operator obtains necessary tips from the tool crib. The tip regulates the size of the flame and it should be obvious that a large tip is never used to cut thin plate. Use the right tip for the job.

Cutting Circular Shapes

The mechanical arrangement shown in Fig. 441 is set up for the purpose of burning circular shapes. The torch is equipped with a tip similar to the one in Fig. 102.

The motion of the torch and the size of the circle to be cut are regulated by the mechanism shown in Fig. 441. The template-tracing unit in Fig. 441 consists of special material, shaped, drilled, and riveted to the plate which is shown held down

by four circular weights. This plate can be shifted from one position to another as required. The arrangement of torches shown in Fig. 442 can be varied to suit requirements. Note the template-tracing unit at the left.

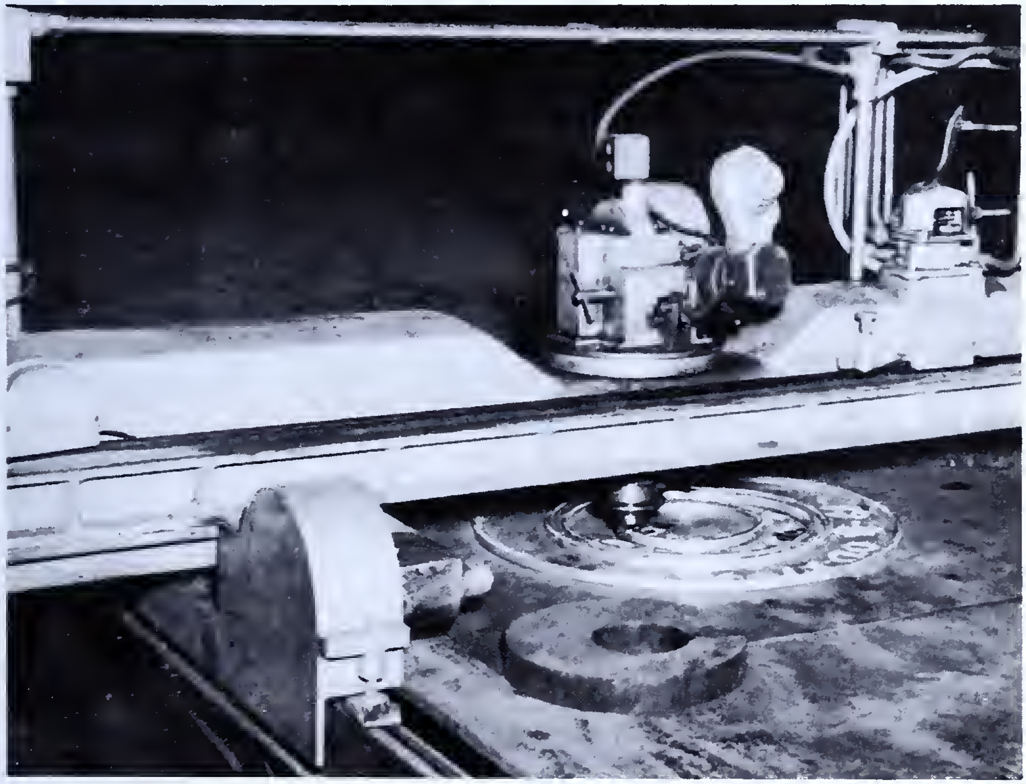


FIG. 441 — *Circular Shape-Cutting Setup*

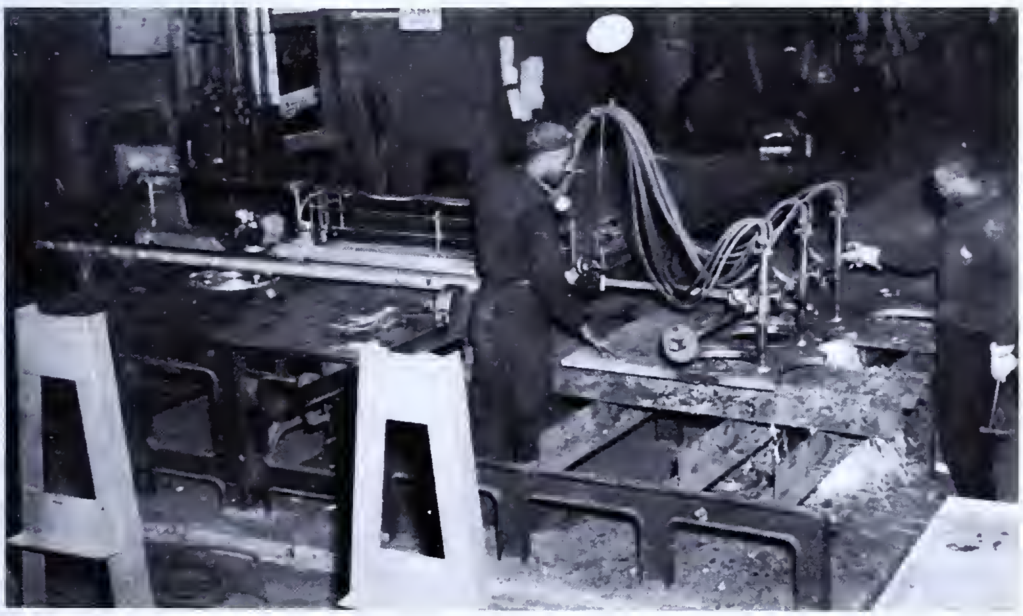


FIG. 442 — *Cutting Three Circular Holes at One Setting*

Portable Radigraph

Frequently plate edges must be beveled to allow for welding; the ends of plates must be cut on an angle; or the leg of a channel or an I beam must be cut out accurately. For these jobs a unit called a Radigraph (Fig. 443) is used to do the cutting. It is an electrically driven machine that runs on a light track. The track can be set at any position on the plate and it is flexible so that it will follow the undulating surface if the undulations are shallow.

Fig. 443 — *Operating a Radigraph*

The torch used is the same as that shown in Fig. 102. It can be tilted in the machine to cut a bevel. On a long cut, two sets of tracks are used. One track can be set ahead of the other as often as is necessary to complete the cut.

The illustration (Fig. 444) shows the unit mounted on an I beam to cut a portion of the flange close to the web.

Note how the operator checks the cut to see if it comes even with the web of the I beam. The track can be adjusted to bring the cut in line with any desired point.

When the operator is directed to do a burning job he should observe the following:

Tools and Equipment

1. Cutting torch
2. Hose lines
3. Radigraph (if used)
4. Rule
5. Adapter
6. Goggles or shield

Procedure (To Burn by Hand)

1. Obtain an adapter from tool crib.
2. Assemble oxygen and gas lines.
3. Attach cutting torch.

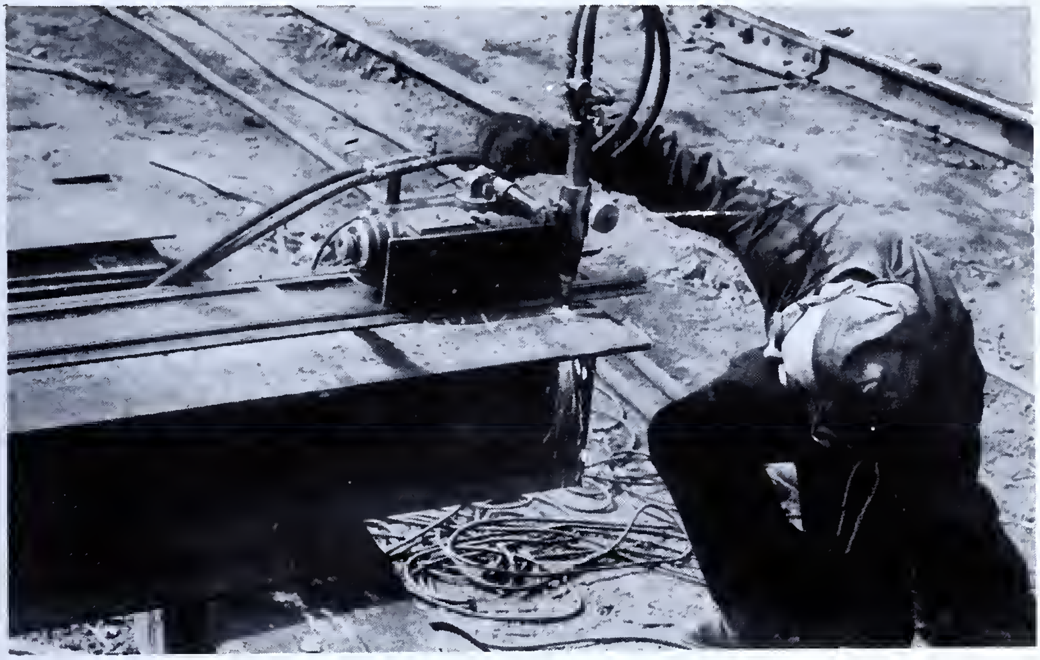


FIG. 444 — *Cutting the Flange*

4. Arrange work to be burned.
5. Assume correct burning position.
6. Proceed to "cut" to the line.

PROCEDURE (If Radigraph is used)

1. Obtain adapter from tool crib.
2. Assemble oxygen and gas hose.
3. Arrange work to be burned.
4. Lay track correct distance from line.
5. Place radigraph unit on track.
6. Adjust torch to correct angle for burning.
7. Begin the cut.
8. Inspect the result of the cutting.

   Do not adjust the torch at first to burn too close to the line if it is possible to allow for adjustment.
9. Make any adjustment necessary.
10. Proceed with the burning.

QUESTIONS

1. On what kind of work is a hand-cutting torch used?
2. To what extent is a Radigraph used in cutting plates?
3. Describe an adapter for a hose line and state its purpose.
4. On some plates the "burn" line and the "finish" line are not the same. Explain.
5. State the location of the two lines and give the reason for the difference between them.

JOB SHEET NO. 22

TO ASSEMBLE TOWER SECTIONS ACCORDING TO LEAD LINE MARKINGS*

General Information

The pressure tower shown in Fig. 349 is fabricated from ¾″ firebox steel. The ¾″ plates which form the sections are rolled to the correct diameter and are then butt welded to form one continuous opened cylindrical shell. A similar long pressure tank is shown in Fig. 445. This tank is made up with a dished head, a cylindrical section marked PL 1, two ring flanges, 7 additional cylindrical sections marked PL 2 to PL 9 inclusive, a conical shaped section, and a cone frustum. When the sections have been prepared they are welded along the girth seams as shown.

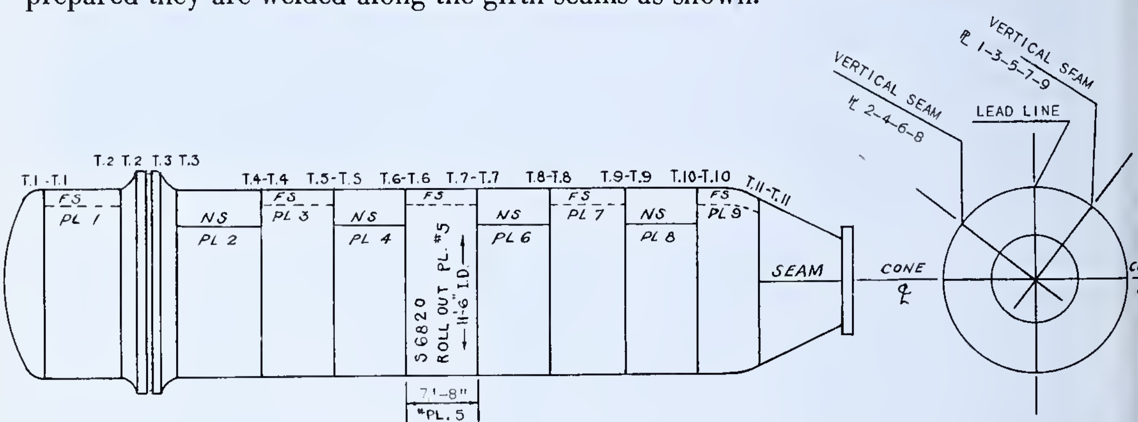


Fig. 445 — *Pressure-Tank Assembly*

Each section is marked with a line and a number so that the welder and the assemblers may be guided in the work of assembling the sections in their proper order.

Lead-Line Markings

The markings on the cylindrical sections (Fig. 446) are put there by the layout man. The markings are located in such a manner that the welded longitudinal seam in each section will not meet the longitudinal seam in the adjoining sections.

Note the *T3* and *T4* marks on the outside of the cylinder in Fig. 446. *T4* matches *T4* on the adjoin-

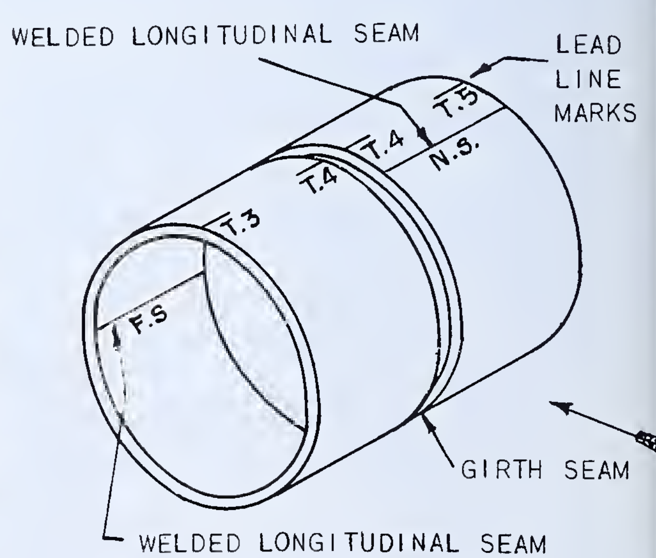


Fig. 446 — *Assembling Sections*

* This is a typical example of Boiler Shop Practice which may or may not be intended for marine use.

ing section. *T5* matches *T5* on the next section (not shown) and *T3* matches *T3* on the section (not shown) on the left.

Note the welded longitudinal seams which are lettered F.S. and N.S. The letters are abbreviations for Near Side and Far Side. When the observer looks at the cylinders in the direction of the arrow the N.S. seam can be seen; the F.S. seam is not seen because it is on the far side of the cylinder.

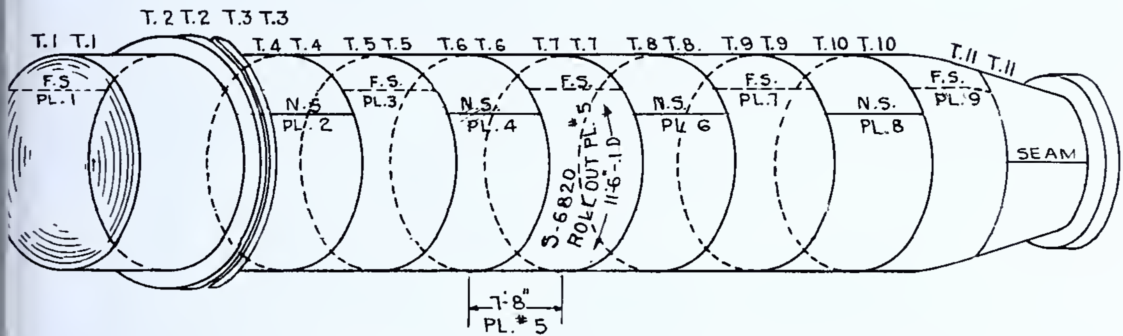


Fig. 447 — *Cylindrical Tank Assembled to Lead Lines According to Plate Markings*

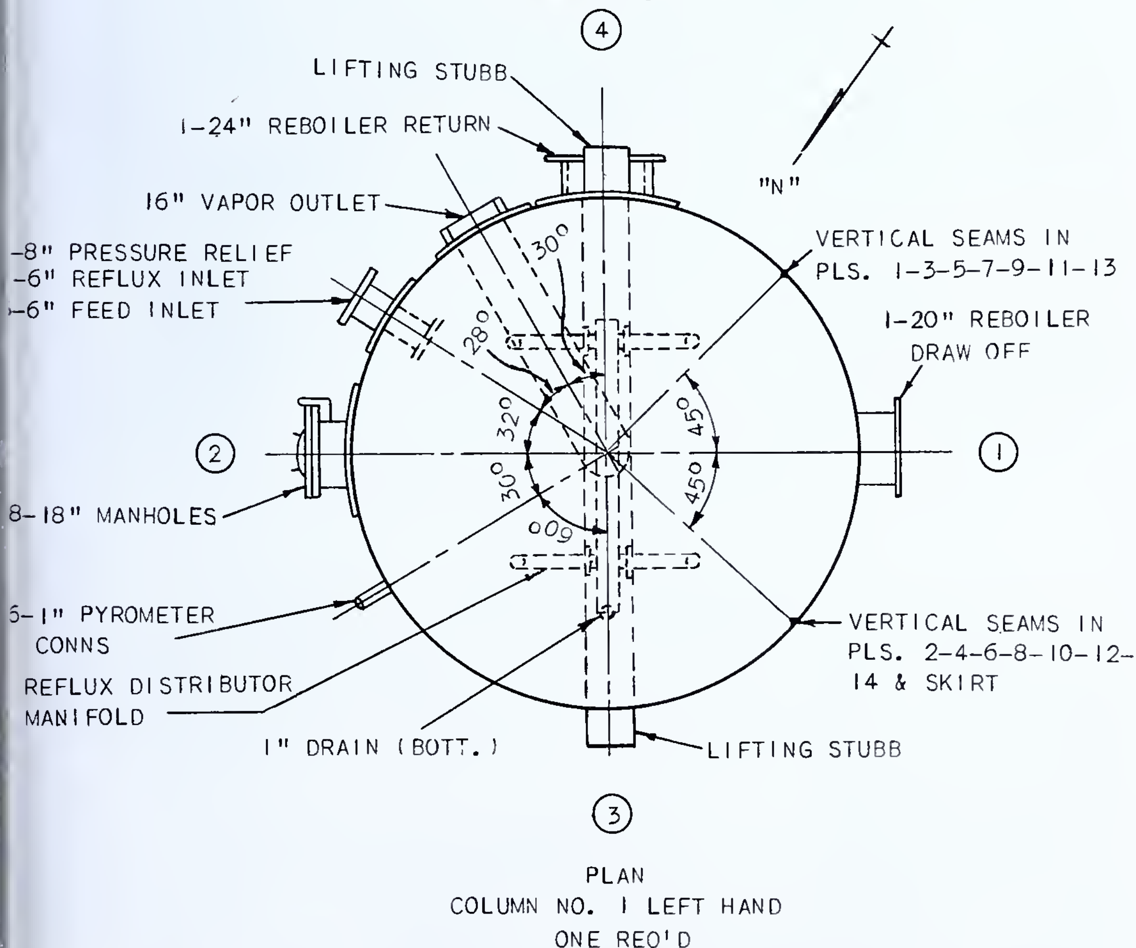


Fig. 448 — *End View of a Cylindrical Tank With Various Nozzles Attached*

A pictorial view of the completed tank is shown in Fig. 447. The markings are followed by the assemblers and the tack welders.

The lead-line markings serve a very useful purpose in addition to assisting the assemblers to stagger the longitudinal seams of the sections. The end view of the cylindrical tank (column) shown in Fig. 448 indicates that several nozzles and other connections are to be welded in place. As each section of the shell is laid out the centers for these items are marked on the shell. The layout man works from the lead-line markings and thus insures the correct relationship of the various connections when the assembly is completed and welded.

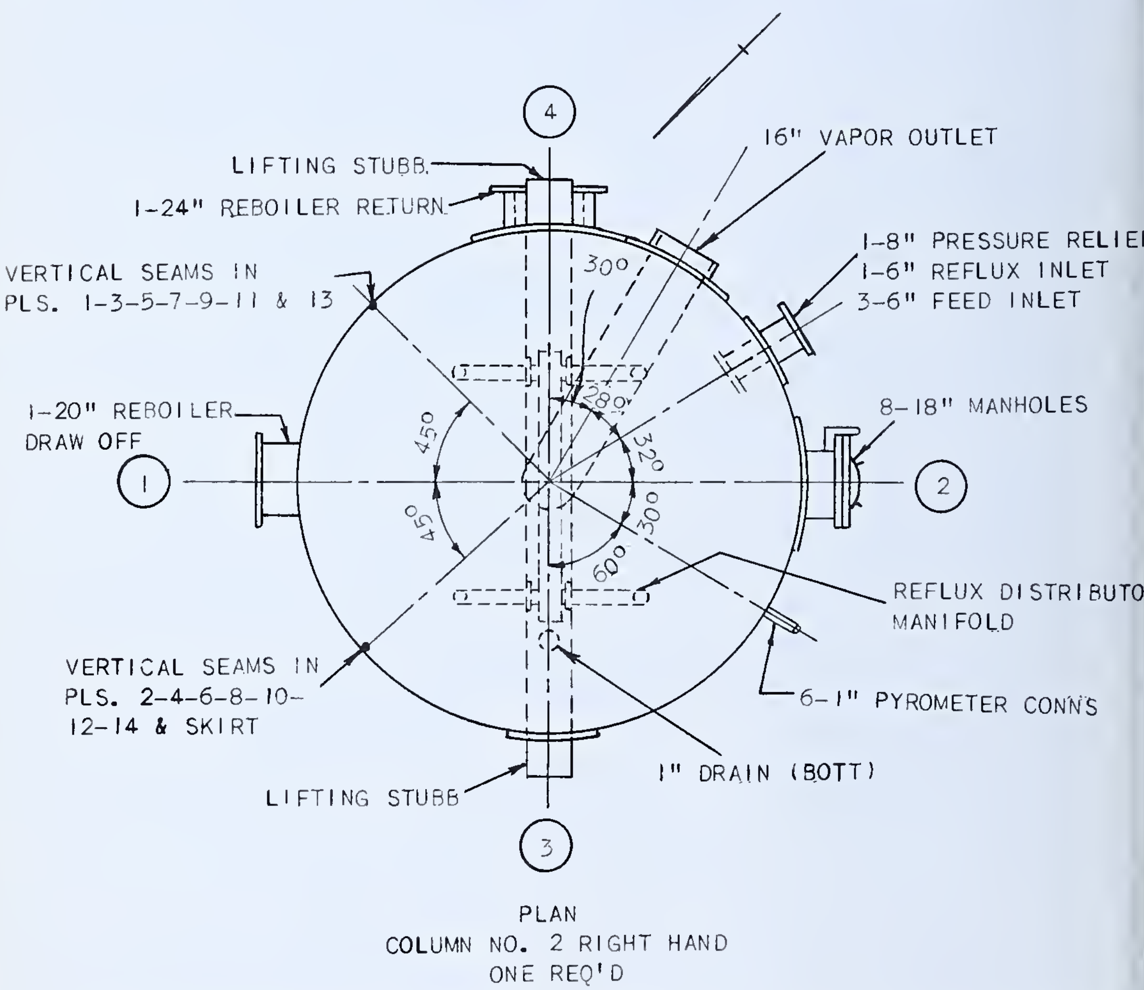


Fig. 449 — *End View of Cylindrical Tank Made the Opposite Hand to Fig. 448*

Tanks Made in Pairs

Cylindrical tanks are often made in pairs as shown in Figs. 448 and 449. Care must be exercised to select the correct section when assembling a tank that mates with another similar tank. The layout man marks the sections R.H. (right hand) or L.H. (left hand). The wrong section could easily be welded in the wrong assembly. The lead-line markings and the lettering on the sections must be carefully followed.

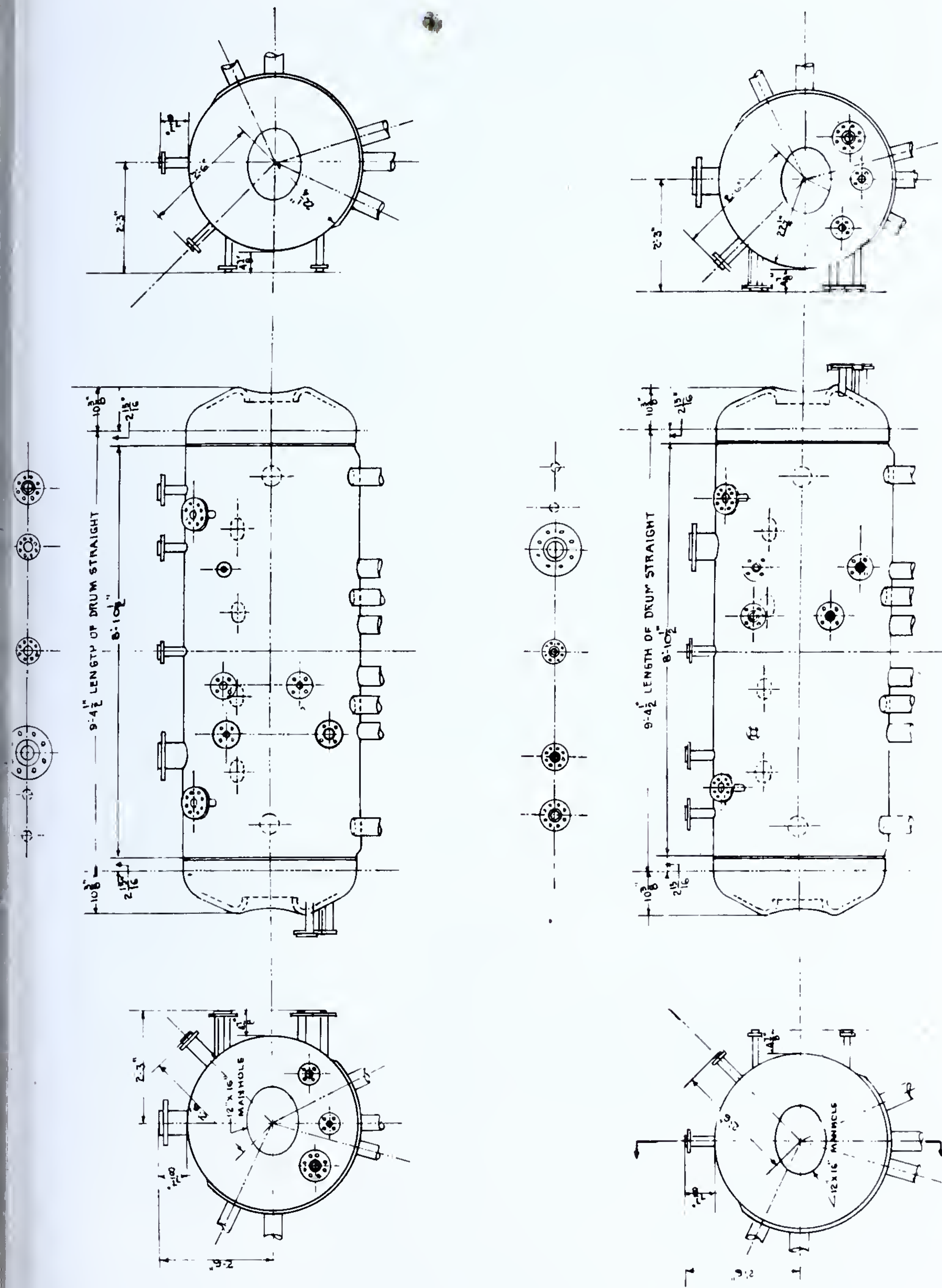


FIG. 450 — *Another Type of Cylindrical Tank as it Appears on the Blueprint*

A typical example of a cylindrical-tank blueprint is shown in Fig. 450. This is a different type of tank from the one shown in Fig. 447. The method of assembling all cylindrical tanks is practically the same. The work of assembling a cylindrical tank may be summarized as follows:

TOOLS AND EQUIPMENT

1. 8-lb. maul
2. Spud wrenches
3. 12″ straightedge
4. Folding rule

MATERIALS

Soapstone
1″ x 4″ bolts and nuts
Two 4″ x 8″ x 1¼″ straps
Two sets angle clips
¾″ x 6″ x 6″ x 6″ angle
Piece 2″ pipe 11′6″ long
Skids 12″ x 12″ x 10″
4 radius blocks

PROCEDURE

1. Study the blueprint and the layout carefully to determine the relationship of the sections.
2. Have the crane crew place the sections in position to be tack welded.
3. Match the lead-line markings on the sections and prepare to tack weld the first two sections.

   The work can be started at either end of the job. See the foreman for instructions.
4. Have the welders tack weld the first two sections.
5. Have the crane crew place the next section.
6. Proceed as in Steps 3 to 5.
7. Proceed to place and have tack welded the remaining sections.
8. Have the job inspected for accuracy.
9. If the work is approved, proceed to have the girth seams welded.

QUESTIONS

1. What are the lead-line markings?

2. When fitting shells together do the longitudinal seams come in the same place on all shells?

3. How is the arrangement of seams shown on the drawing?

PART VIII

*ERECTING A BABCOCK AND WILCOX MARINE SECTIONAL HEADER WATER-TUBE BOILER

JOB SHEET NO. 23
TO ERECT FIREBOX STEEL STRUCTURE

General Information

A Babcock and Wilcox single-pass marine boiler is usually standard equipment in a tanker or a freighter. It is constructed of steel shapes and water tubes of various sizes. The space enclosed between the steel and tube construction is the furnace, or combustion chamber, in which the fuel is converted into heat. This furnace is commonly referred to as the firebox. The walls of the furnace, or firebox, are so built that large water tubes are inclosed, and as the water passes through these tubes it cools the refractory material surrounding the tubes and then goes on into tubes and coils built into the upper part of the unit where it is converted into steam.

The Furnace

The furnace is designed specifically to meet marine requirements of compactness and efficiency. Chrome ore, which is a refractory material, is packed into the spaces between the tubes in the side and rear walls to prevent a waste of heat which would result if the flames were allowed to shoot through between the tubes. This refractory material is subjected to intense heat produced by the fuel oil. The passage of the water through the tubes in the side walls reduces furnace-wall temperature.

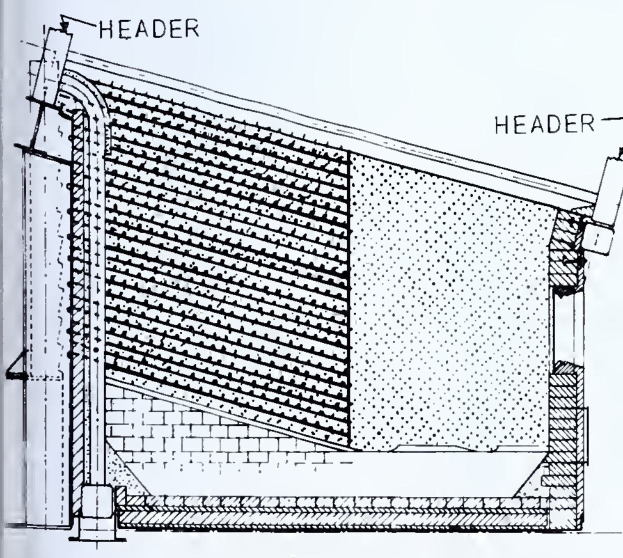


Fig. 451 — *Side Furnace Wall*

Installing the Refractory Lining

The refractory lining is held in place by means of studs projecting from the outside of the tube. These studs are welded in place. The tubes are studded all around for half of their length at the front of the firebox. The rear halves of the tubes are studded on the outside diameters which face each other. See Fig. 451.

* Line drawing illustrations Courtesy of Babcock and Wilcox.

The chrome ore refractory is packed around and between the partially studded tubes at the rear. The rear furnace wall also is composed of partially studded tubes. See Fig. 452. Three cross sections in Fig. 453 show chrome ore refractory packed around the tubes.

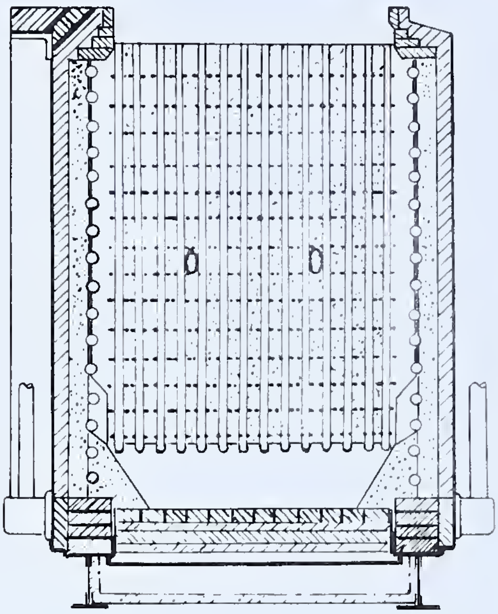


Fig. 452 — *Rear Furnace Wall*

The furnace is equipped with two peepholes in the rear. There is an access door in the front. The furnace is fired by four Babcock and Wilcox oil burners with mechanical-type atomizers.

Erecting the Boiler

Some of the items which go into the building of a marine boiler are units in themselves; other items are single pieces which must be fitted into their respective positions as the construction of the boiler proceeds. This instruction sheet outlines the procedure for beginning the construction of a boiler. The following instruction sheets will outline the steps necessary to build a completed boiler.

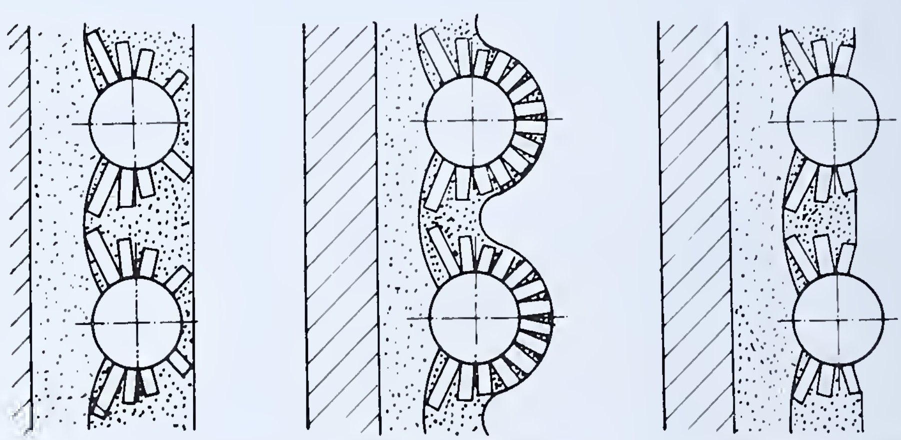


Fig. 453 — *Furnace-Wall Cross Sections Showing Chrome Ore Insulation*

Tools and Equipment

1. 2—5/8″ hexagon spud wrenches
2. 1—1″ hexagon spud wrench
3. 1 pinch bar
4. 1—3/4″ hexagon spud wrench
5. 1—2-lb. ball-peen hammer
6. 1—8-lb. maul
7. 2—12′ pendants
8. 2—3/4″ shackles
9. 1—4′ choker
10. 1—2′ choker
11. 4—5/8″ drift pins

MATERIALS

Johns-Manville aertite coating

82 — 5-B-10	16 — 5-B-12	40 — 6-B-16	4 — 7-B-20
16 — 5-B-11	14 — 5-B-26	24 — 6-B-18	8 — 8-B-20

FIG. 454 — *Jig and 12" x 12" Timbers on Which Boiler is to be Erected*

PROCEDURE

1. With the crane (Fig. 455) place side water wall on jig (Fig. 454). The jig layout is shown in Fig. 457. Notice the rigging attached to water wall and the length of pendants. This method of picking up the side water wall is safe and will cause base of side water wall to hang perpendicular to the jig.
2. Line up holes in base of side water wall with holes in jig. (Use a pinch bar to align the holes).
3. Insert 8-B-20s, using a 1" hexagon spud wrench to tighten the nuts.
4. Lower the crane hook and remove choke pendants.
5. Hook on to opposite side water walls and proceed as in Step 1.

FIG. 455 — *Picking up a Side Water Wall for Placing on Jig*

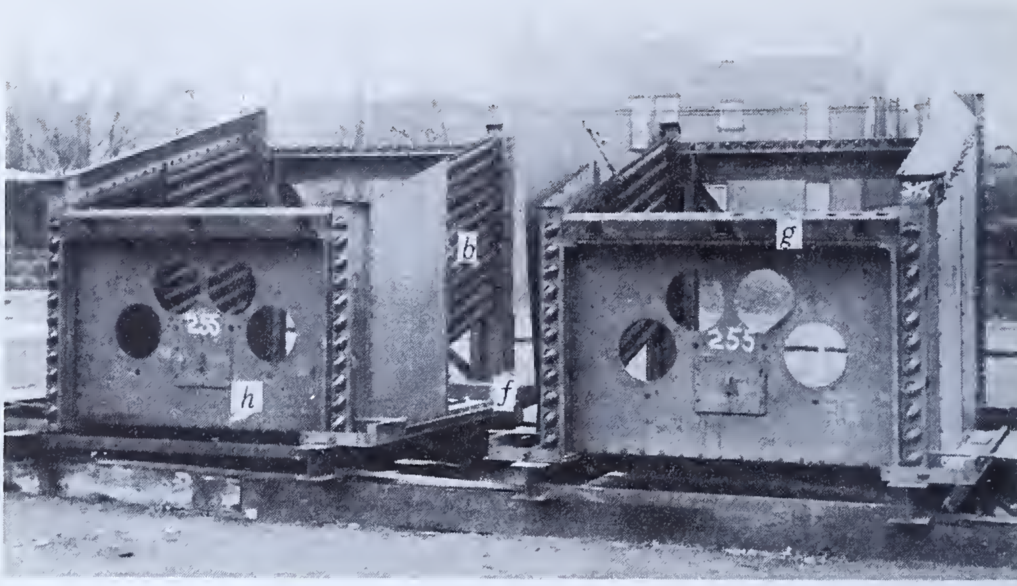


FIG. 456 — *Side Water Wall (b), Rear Water Wall Header (f), Mud Drum Header (g), and Inner Front Plate (h) in Position*

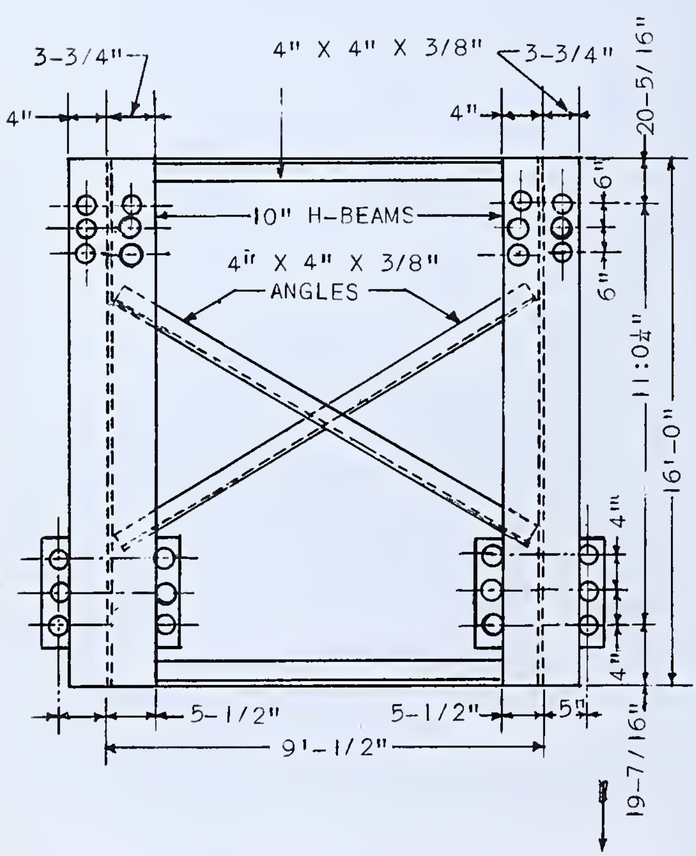


FIG. 457 — *Jig Layout*

6. Hook on to pc. mk. BP1 so that it will hang level; move it into position between side water walls and bolt it to side water wall base. Use 5/8" drift pin and hammer and drift the holes fair. Bolt together with 5-B-10s.

   NOTE: BP1 means Brick Pan No. 1.
   BP2 means Brick Pan No. 2.

7. Hook on to pc. mk. BP2 and follow same procedure as in Step 6.

8. Place pc. mk. BP3 behind pc. mk. BP1 and pc. mk. BP2 and align it with bolt holes. (Use the crane to lift BP3.)

9. Bolt pc. mk. BP3 to pc. mk. BP1 and pc. mk. BP2 with 5-B-12s and 5-B-10s.

Coat the bolted joints with Johns-Manville aertite between all the flanges. The coating prevents infiltrations of air through the boiler settings.

10. Place inner front plate pc. mk. FP1. Loosen foundation bolts in front of boiler to permit ample clearance. Fair all holes with 5/8″ drift pins, and bolt fast with 5-B-10s. See Fig. 456.

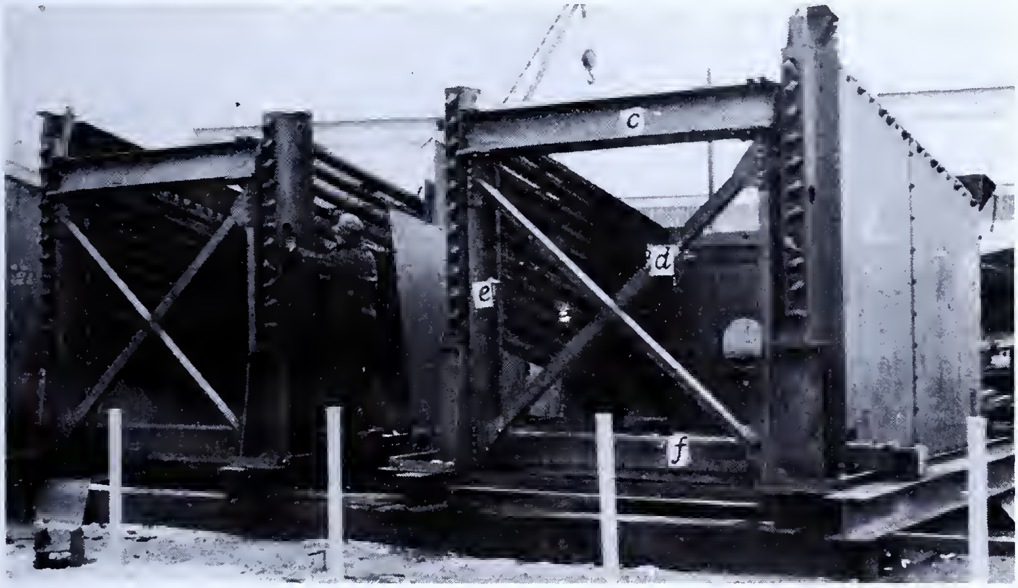


Fig. 458 — *Rear of Boiler Ready for Steam-Generating Sections. Channel Supports (e); I Beam (c); Rear Angle Brace (d); Rear Water Wall Header (f).*

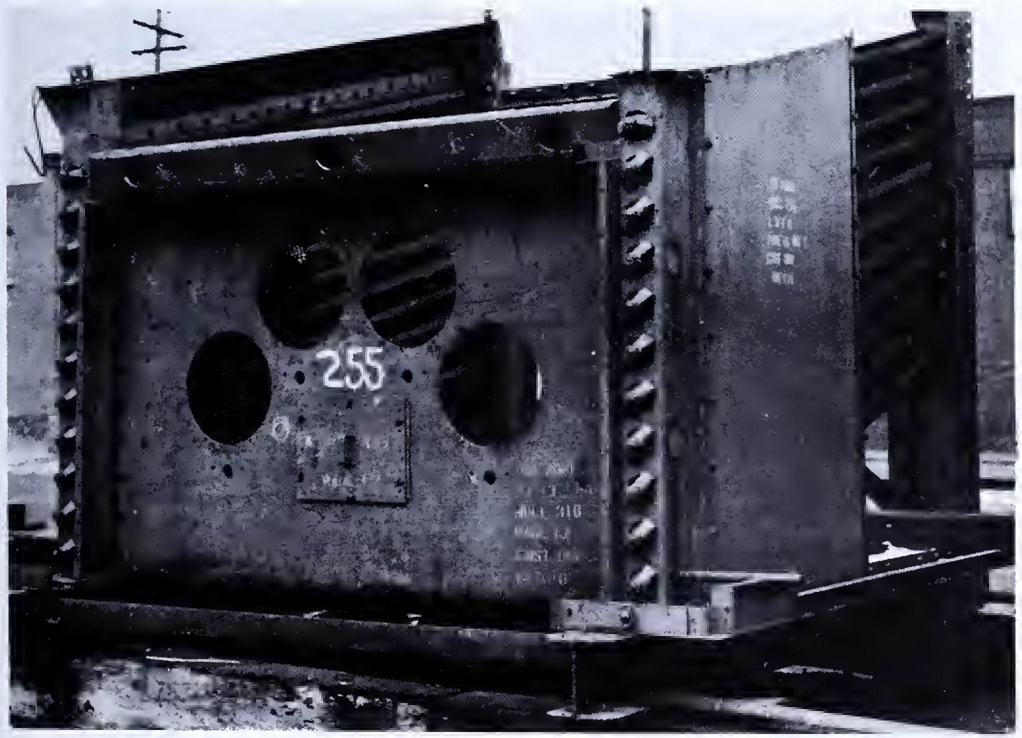


Fig. 459 — *Firebox Ready for Sections to be Installed*

11. With crane, place structural channel on rear water-leg pc. mk. UC right, and bolt up with 6-B-18s. Then place structural channel, pc. mk. UC left, and follow same procedure as above. See Fig. 458, at *e*.
12. With crane, place diagonal angle braces at rear boiler, pc. mk. UA, as shown on Fig. 458 at *d*, and bolt into place with 6-B-16s.
13. With crane, place rear I-beam header support, pc. mk. U1, and bolt into place using 6-B-16s. See Fig. 458 at *c*. Also install 5-B-28s in the holes provided. Make sure that these holes have been tapped before trying to install the bolts.
14. Install mud drum as shown, allowing clearance. See Figs. 456 and 460. A cross section of the mud drum is shown in Fig. 461. Line up center punch marks on

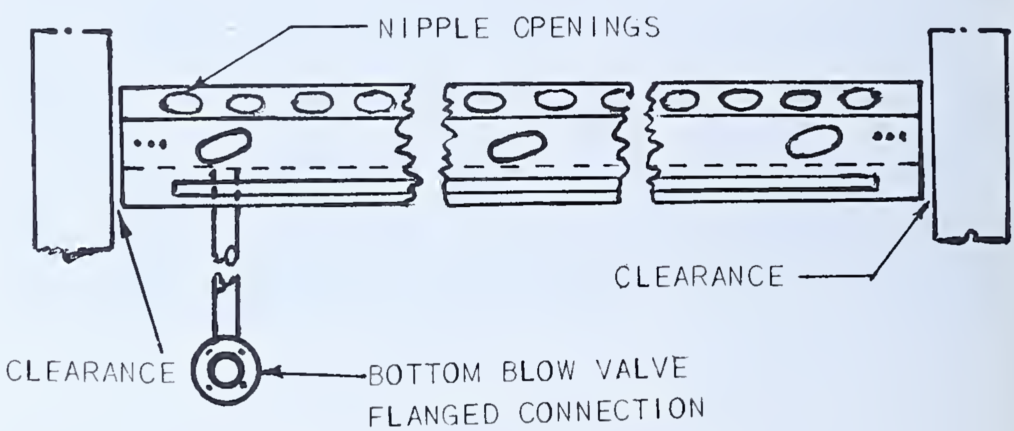


Fig. 460 — *Mud Drum Installed*

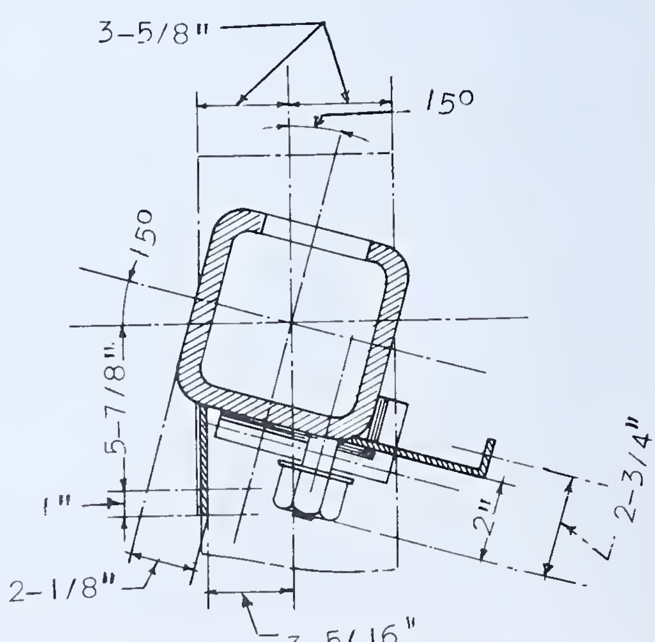


Fig. 461 — *Mud Drum Cross Section*

the mud drum, using shims. See Fig. 462. Bolt in place to pc. mk. FP1 and tighten nuts on bottom of mud drum.

15. With crane, place rear water wall header inside pc. mk. BP3, with tube holes up. See Fig. 458 at *f*.

16. Re-check on all nuts and bolts to make sure they are tight. Tack weld all nuts as noted on the drawings. The firebox is now ready for installation of sections. See Fig. 459.

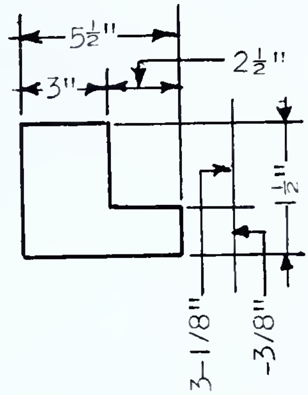


FIG. 462 — *End View of Shim*

QUESTIONS

1. **What is a furnace?**
2. **Explain the different types of furnaces.**
3. **What type of side and rear water walls are used in a Babcock and Wilcox furnace?**
4. **With how many burners is this type of boiler equipped?**
5. **Name the first section placed on the jig.**
6. **What size of bolts and nuts are used to bolt pc. mk. BP1 and pc. mk. BP2 to the base of the side water wall?**
7. **Why is Johns-Manville Aertite used?**
8. **What difference is there between structural channels on rear water-legs?**
9. **How is a mud drum lined up?**
10. **Are tube holes in rear water wall header facing up or down?**

JOB SHEET NO. 24

TO ERECT AND ALIGN SECTIONAL HEADERS

General Information

A sectional header is a hollow steel casting which serves as a manifold into which are expanded the generating and circulating tubes. When in place, the headers become the steam generating surfaces. Drawing No. 463 (in envelope at back of book) shows radiant and convection steam-generating surfaces. The generating tubes are 1¼″ O.D. They are staggered to eliminate the use of baffles and form a single-pass for the furnace heat and gases. Hence, the type name of the boiler, "single-pass."

The headers are equipped with handholes and caps to permit quick and easy erection, repairs, and inspection.

Sectional Header

A sectional header is composed of 8 2/3 clusters of nine 1¼″ tubes to a cluster; 2/3 clusters of nine 1¼″ tubes to a cluster; and 1 cluster of four 2″ tubes, all of which are 11′ 0″ long, written on the blueprint in the boiler formula as follows:

8—2/3	(9—1¼)	
2/3	(9—1¼)	11′ 0″
1	(4—2)	

Handhole Caps

The handhole caps are made up of a cap, dog, and nut. It will be noted (see Fig. 464) that the cap has a machined lip or spigot and a machined seat or recess inside the handhole. A gasket is installed between the handhole and the cap machined surfaces. When the dog is drawn down tightly, a leak proof joint is formed. See Fig. 464.

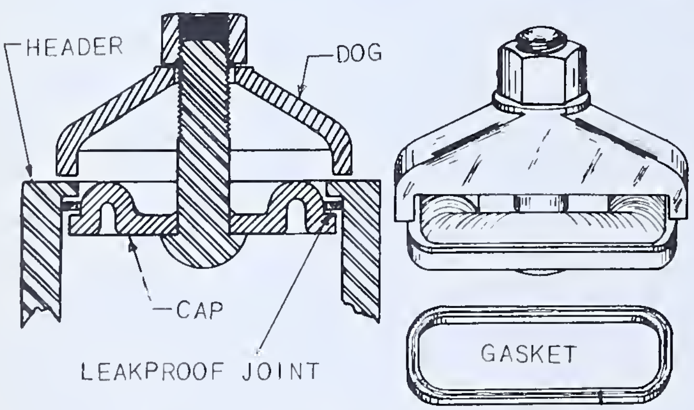


Fig. 464 — *Handhole Cap and Gasket*

Great care should be exercised in the handling and installations of these caps, as the slightest nick in the gasket or on the lip spigot of the cap will result in a leaky handhole cap.

Reference: Drawing No. 463 is in an envelope at the back of this manual. Take it out to use as a reference for the study of this job sheet.

Tools and Equipment

1. 1—½-lb. ball-peen hammer
2. Pinch bar
3. Large wooden square
4. 1—⅛″ spud wrench
5. 2—12′ pendants
6. 2—¾″ shackles
7. 1—4′ choker
8. 1—2′ choker
9. 2 iron wedges
10. 14—½″ nuts
11. ⅛″ and 1/16″ shims 1″ square
12. ⅝″ spud wrench
13. 1 chalk line
14. 1 space bar
15. 1 fifty-foot hand line

Materials

Mud drum

Nipple

Chalk

Fig. 465 — *Setting First Boiler Section*

Procedure

1. With first section hooked up in position as shown in Fig. 465, align it with a large square. Use a ½″ nut between the bottom of the downtake header and top of the mud drum. See Fig. 466.
2. Line up with a mud-drum nipple the tube hole in bottom of downtake header with the tube hole in top mud drum, so that the nipple will move freely in both holes at the same time. Use jacking bolts in rear I beam to accomplish this.

3. After this alignment has been made, secure section at downtake header to some stationary object as shown in Fig. 465, and tighten bolt at bottom of uptake header to I beam.
4. Land remaining sectional headers (shown in Fig. 465, at the right) lashing each following section to the preceding one. Make sure that No. 3 and No. 4 soot-blower bearings (Fig. 467) are correctly installed as shown on blueprint.

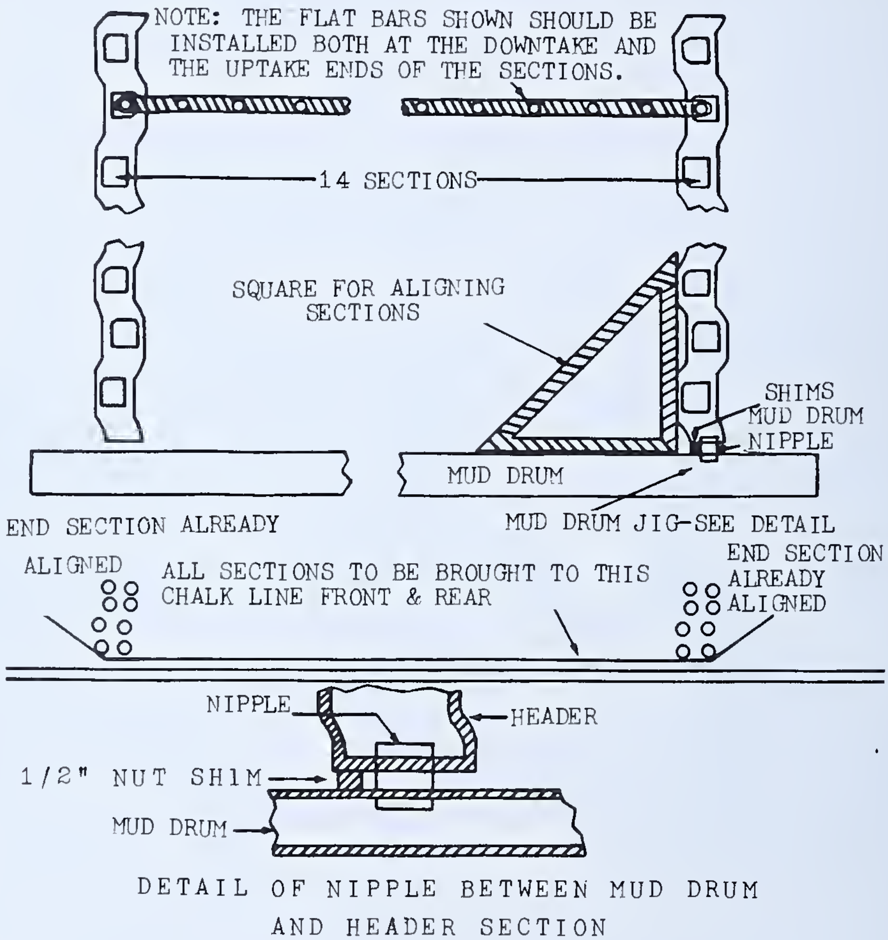


Fig. 466 — *Boiler Section Setting Details*

5. When all sections have been installed, adjust them for correct height as shown on the blueprint. Proceed as follows:
   (a) Snap a chalk line across center of mud drum on furnace side, using the center punch marks which are there for that purpose.
   (b) Measure from chalk line to bottom of fire-line tubes and shim up or down to height required on the blueprint.
   (c) Continue with the remaining sections in like manner. Be careful to hold the measurement given on the blueprint.
6. Place flat bar across entire length of downtake sections between dogs on handhole caps and nuts as shown in Fig. 466.

7. Bring sections into alignment fore-and-aft by the use of the jacking bolts in rear I beam so that a mud drum nipple will drop freely through tube holes.
8. Stretch a line across the furnace side of the uptake sections and bring sections at rear water wall tube holes into line, using shims to hold height.
9. Re-check all measurements taken and consult leader to double-check measurements. A mistake at this point of construction will cause future trouble.

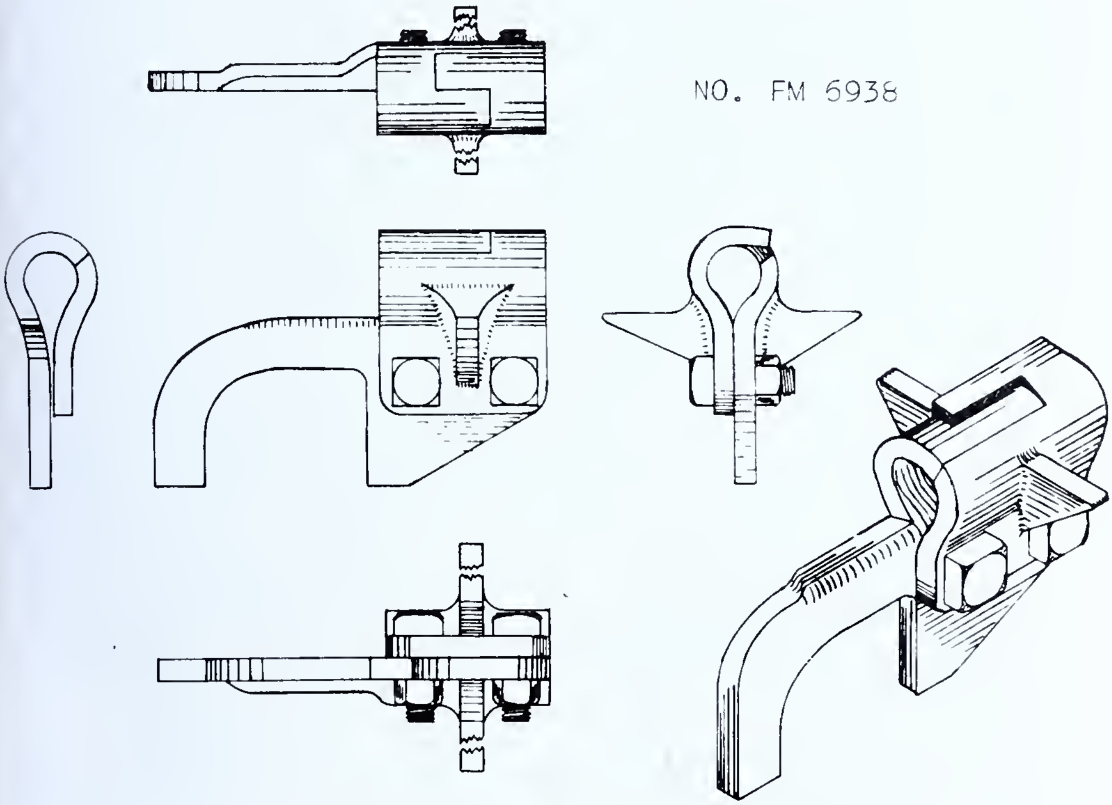


FIG. 467 — *No. 3 and No. 4 Soot-Blower Bearing*

QUESTIONS

1. What is a sectional header?
2. What is the purpose of a header?
3. What size are the generating tubes?
4. Why are the sections staggered?
5. Why should handhole caps be handled with care?
6. What tool is used to line up the vertical position of the first section installed?
7. On which tubes are No. 3 and No. 4 soot-blower bearings attached?
8. From what point is the measurement taken to determine the height of the downtake headers?
9. For what purpose are the jacking bolts used?

JOB SHEET NO. 25
TO INSTALL MUD-DRUM NIPPLES

General Information

The steam-generating tube section of the boiler is located directly above the furnace or firebox. Figure 468 shows the relationship of these two sections. Figure 463 (in envelope at back of book) is a side view of the same two sections showing how the steam-generating tube section meets the firebox section at an angle. The front of the steam-generating tube section is lower than the rest. The angle of inclination is 15 degrees.

Feedwater Impurities

The feedwater is treated with a compound to eliminate the impurities that are found in all water. The impurities are not always completely eliminated; after a time they form a coating on the tubes which will build up and form a scale. If the scale is allowed to form, the furnace will not heat water efficiently and the tubes will become pitted and have to be replaced before they serve their full term of usefulness. To summarize, scale shortens the life of the tube and lowers its efficiency.

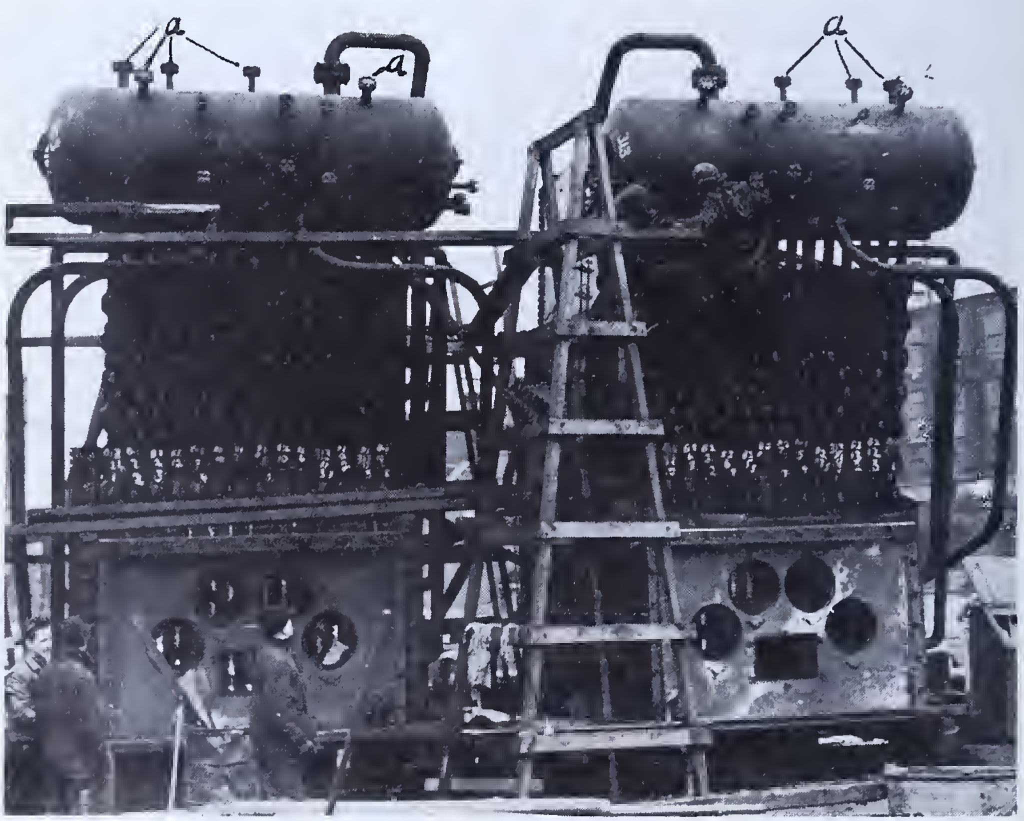


Fig. 468 — *Boilers Ready for Preliminary Hydrostatic Test; all Tubes and Saturated Steam Line in Position. Note Use of Blanks (a) Instead of Boiler Mountings*

The Blow-Down

Before the impurities in the water have time to form scale, steam pressure is used to blow them out through the blow-down pipe shown at *b*, Fig. 469. Of course the impurities must be collected for the blow-down operation to be successful. Figure 469

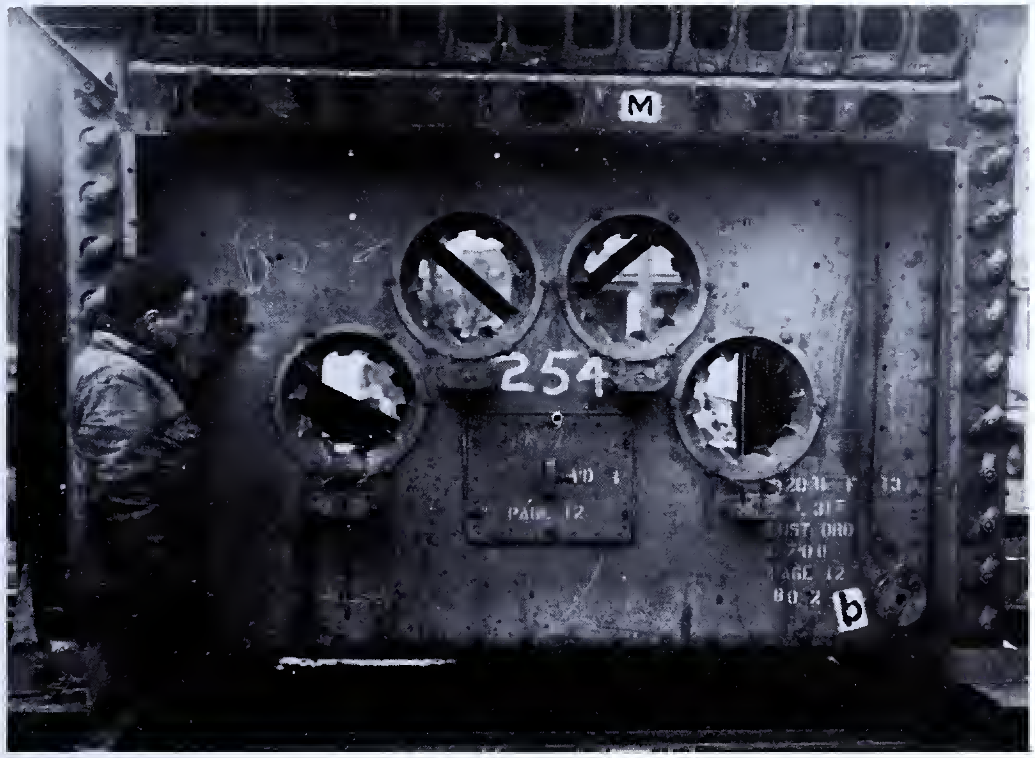


Fig. 469 — *Inner Front Plate Showing Bladed Cones, Riders and Drains, Access Doors and Blow-Down Pipe*

shows a mud drum at *m*. It will be seen in Fig. 469 that the mud drum is located at the bottom of the downtake sections, or as they are sometimes called, sectional headers. As the feedwater circulates through the system the impurities are deposited by gravity in the mud drum.

At least once every twenty-four hours the blow valve on the end of the blow-down pipe (*b*, Fig. 469) is opened, and the boiler pressure scavenges (blows out) the "mud" that has collected in the mud drum.

Installing the Nipples

The downtake sections are connected to the mud drum by nipples. See Fig. 472. The nipples are expanded into the mud drum and downtake sections.

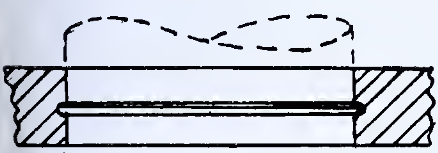


Fig. 470 — *Serrated Tube Seat*

Suitable holes are provided in the downtake sections and in the mud drum to receive the nipples. See Fig. 470. The groove in the hole shown in Fig. 470 allows the tube to expand. This hole is called a tube seat, and the groove in the hole is called a serration. Serrated holes

are used in various places in boiler construction. These locations will be given in subsequent job sheets as the occasion arises. The nipples are installed after the header sections, mentioned in Job Sheet No. 12, are in place.

Reference: Drawing No. 463 is in an envelope at the back of this manual. Take it out to use as a reference for the study of this job sheet.

Tools and Equipment

1. 1 Expander No. 7567
2. 1 Mandrel No. 66
3. Hammer
4. 1 Extension bar
5. 1 Split brass bushing
6. 1—7/8″ Universal
7. 1—1/4″ x 3″ Flat bar—30″ long
8. 1 No. 5 Compound tube-expanding machine
9. 1 Expander No. 4393
10. 1—12″ half-round bastard file
11. 2 Iron wedges

Materials

14 Mud-drum nipples
Kerosene
Rags
Emery cloth
Tubalube grease

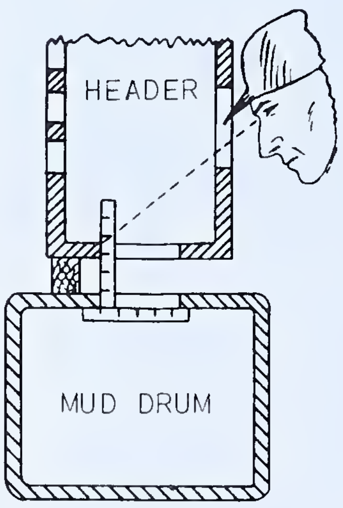


Fig. 471 — *Measuring for Nipple Length*

Procedure

1. Procure the correct quantity of mud-drum nipples from the boiler erecting shop storeroom and clean them inside and outside with kerosene, rags, and emery cloth.
2. Clean the serrated tube seats in the downtakes and mud drum.
3. Measure the length of each nipple as shown in Fig. 471.

The 6″ scales are used to take this measurement. Each location must be measured individually and the lengths are recorded on a sheet of paper. Mark the downtake header to which each nipple belongs. Add 3/4 of an inch to the measured length of each nipple. This extra 3/8 of an inch on each end of the nipple is provided for the purpose of flaring the nipple ends. See Fig. 472.

4. Send them, with the measurements, to the machine shop to be cut to length.

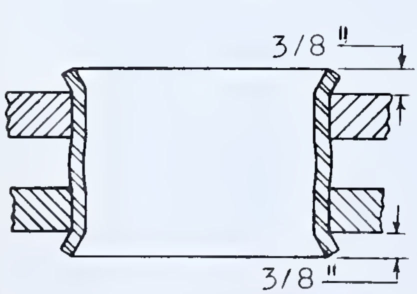


Fig. 472 — *Nipple Expanded*

Fig. 473 — *No. 66 Mandrel*

5. Install a nipple in the end serrated hole (start at either end) of the mud drum and downtake header. Push the nipple up through the mud drum allowing it to project 3/8 of an inch above and below the inside surfaces. See Fig. 472. Hold the nipple in position with a short length of flat bar inserted in the space between the mud drum and the downtake. See Fig. 474 at *a*.
6. Insert expander No. 7567 in the second handhole from the bottom of the first sectional header.
7. Insert mandrel No. 66 (See Fig. 473) in the expander No. 7567. See Fig. 475.
8. Use a hammer to tighten the mandrel snugly in the expander.
9. Attach universal on mandrel No. 66 in the expander No. 7567.
10. Lower an extension bar, through a brass bushing, Fig. 476, from the top side of the sectional header into the universal in Step 9. See Fig. 474.
11. Place the No. 5 compound tube expanding machine. (Fig. 477.)
12. Have helper hold a flat bar against the nipple to keep it in place and start the expanding machine to rotate slowly in a clockwise manner.

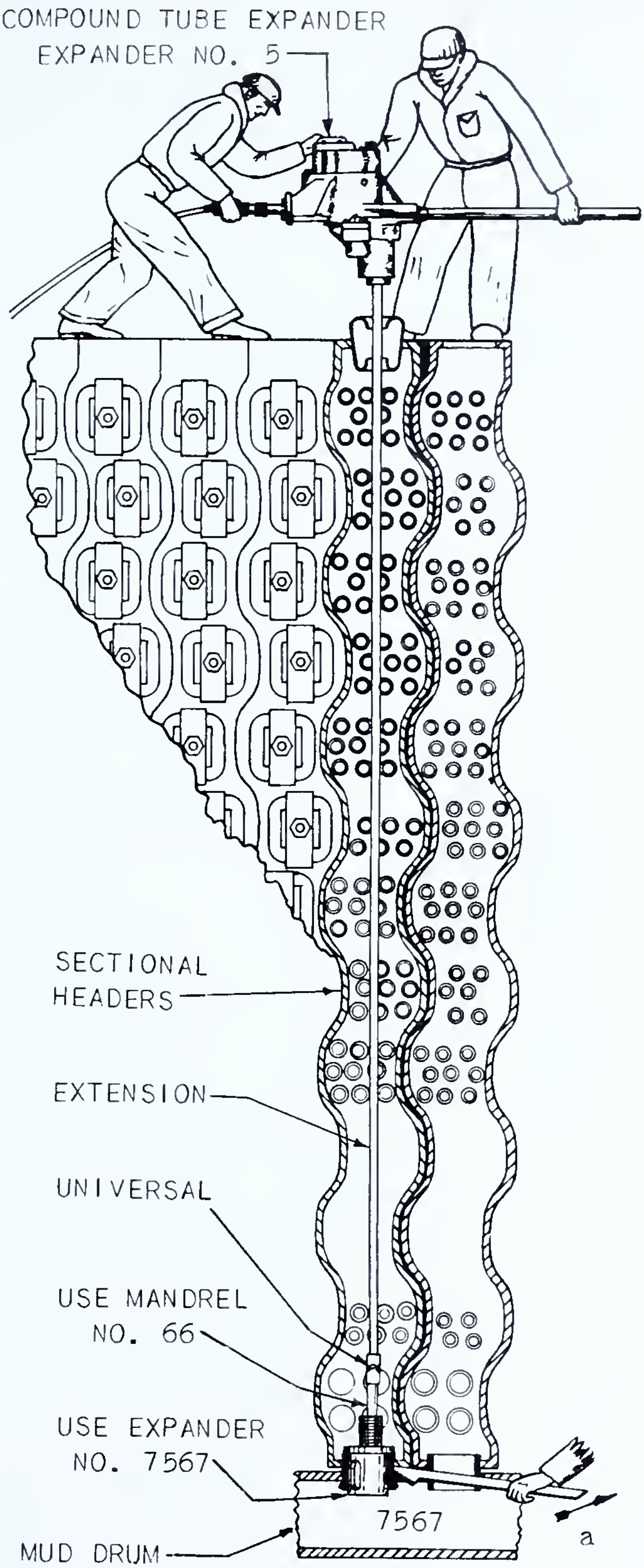


Fig. 474 — *Expanding*

13. Roll the nipple until it is correctly expanded and flared into the serrated tube seat of the mud drum. See Fig. 472.
14. Reverse the rotating direction of the expanding machine.
15. Remove the expanding machine, extension, universal, mandrel, and expander.
16. Insert expander No. 4393 in the bottom handhole of the first sectional header.
17. Insert mandrel No. 66 in the expander No. 4393.
18. Use a hammer to tighten the mandrel snugly to the expander.

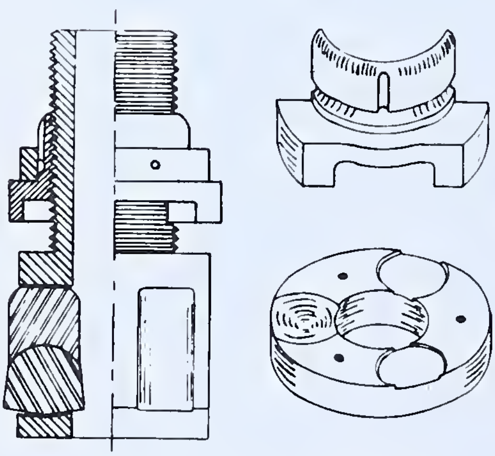


FIG. 475 — *No. 7567 Expander*

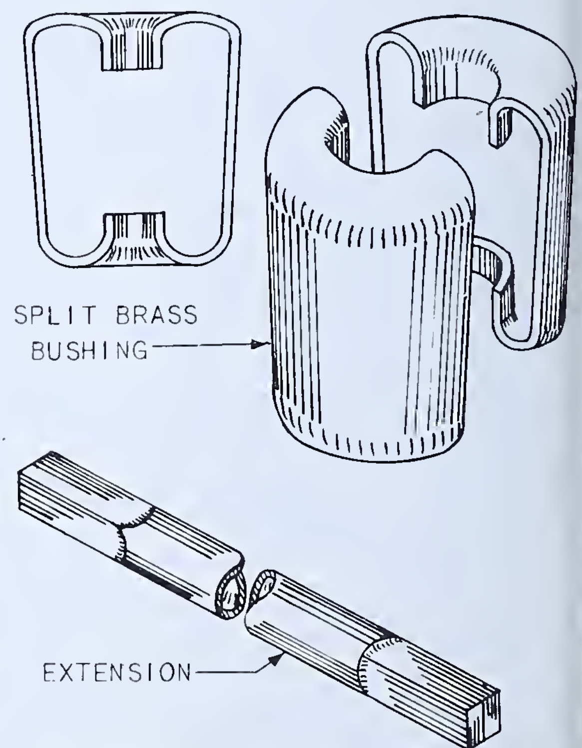


FIG. 476 — *Split Bushing and Extension*

19. Place universal on square end of mandrel No. 66.
20. Lower an extension bar from the top side of the sectional header into the universal in Step 9.
21. Place the compound tube-expanding machine over the end of the extension bar.
22. Start the expanding machine to rotate slowly in a clockwise direction. Fig. 478.
23. Roll the nipple until it is correctly expanded and flared into the serrated tube seat of the mud drum.
24. Reverse the rotating direction of the expanding machine.
25. Remove the expanding machine, extension, universal, mandrel, and expander.
26. Proceed in the same manner with the other mud-drum nipples which are to be installed.

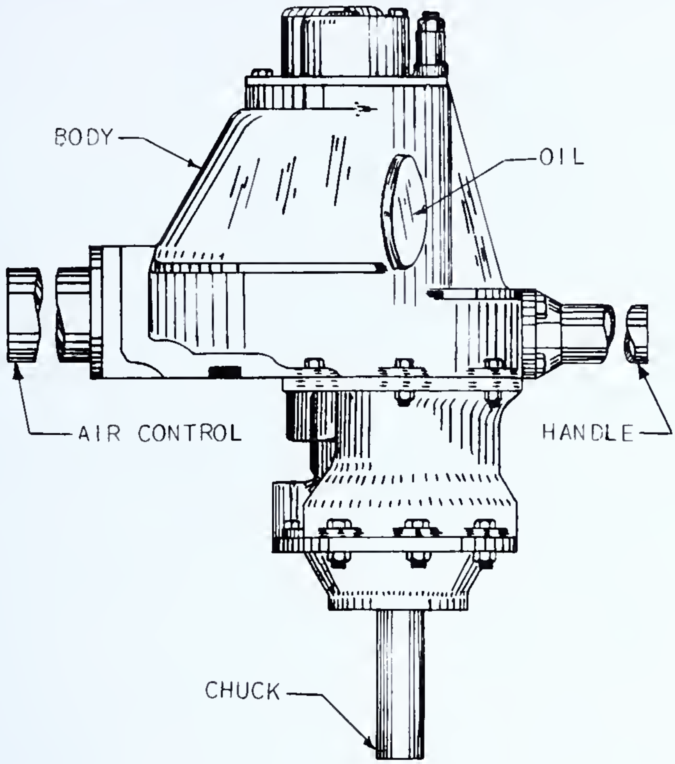


FIG. 477 — *No. 5 Compound Expanding Machine*

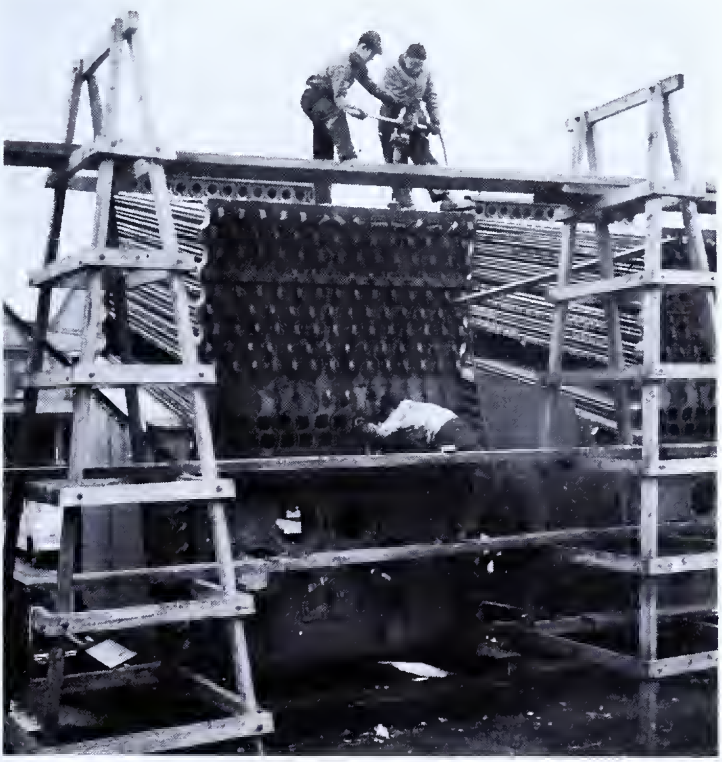


FIG. 478 — *Expanding Mud-Drum Nipples*

QUESTIONS

1. What is a mud drum?
2. Where is the mud drum located?
3. Why is it important to clean nipples and tube seats before the nipples are installed?
4. How is the length of a mud-drum nipple obtained?
5. What is the length of projection of the mud-drum nipples?
6. Which end of the nipple is expanded first?
7. Why is a nipple flared?
8. Why is a split brass bushing placed around the extension?
9. When is a nipple correctly expanded?

JOB SHEET NO. 26

TO INSTALL THE STEAM DRUM

General Information

The steam drum is shown in Drawing 463. (In envelope at back of book.) The feedwater inlet nozzle is shown at *A*. As indicated by the term feedwater, the water is fed into the boiler through the inlet nozzle. The downtake nipples are shown at *H*. At the time the steam drum is installed these nipples are expanded in the openings provided in the steam drum and in the downtake headers *K*.

The feedwater flows down through the nipples, through the downtake headers, through the generating sections, up through the uptake headers, into the circulating tubes, and back into the steam drum. The circulating tubes are expanded in the openings provided in the steam drum and in the front of the boiler; the uptake headers *K* are located at the rear of the boiler. These expanding operations are performed as one job. The steam drum is installed in the manner described to form the final link in the steam-generating system.

Tools and Equipment

1. 1 Expander No. 4294
2. 1 Mandrel No. 60
3. 1 Mandrel No. 66
4. 1 Expander No. 7391
5. 1 Mandrel No. 44
6. 1 Mandrel No. 48
7. 1 Expander No. 7397
8. 1 Mandrel No. 58
9. 1 Mandrel No. 62
10. 1 Expander No. 7392
11. 1—7/8″ extension coupling
12. 1—7/8″ extension—12″ long
13. 2—4″ tube clamps
14. 2—4½″ tube clamps
15. 2 Special jacks
16. 1—7/8″ spud wrench
17. 2 Tie-bars—10′ 6″ long
18. 1—1-ton chain hoist
19. 2—24″ chokers
20. 1—8-lb. maul
21. 1—1½-lb. ball-peen hammer
22. 1 Brass bar, 1½″ dia., 18″ long
23. 1—24″ level
24. 1—12″ level
25. 1—50′ steel tape
26. 1 No. 5 Compound expanding machine

Materials

14 circulating tubes
14 downtake nipples
Tubalube grease
Kerosene
Rags
Emery cloth

Procedure

1. While the steam drum is on the ground, enter the manhole and clean the inside thoroughly with kerosene rags.

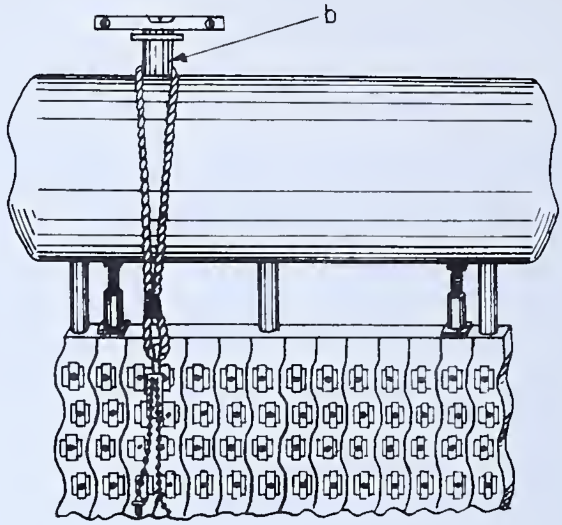


FIG. 479 — *Leveling the Mud Drum*

2. Place special jacks, Fig. 483, on sections of the downtake headers as shown in Fig. 479 and in Fig. 481. (The jacks are on the second sections from each end.)
3. Place tie rods through the uptake headers (as shown in Fig. 480) in readiness to tie fast the steam drum when it is raised into position.
4. Have the riggers hook the steam drum in a level position on the special jacks shown in Fig. 481.

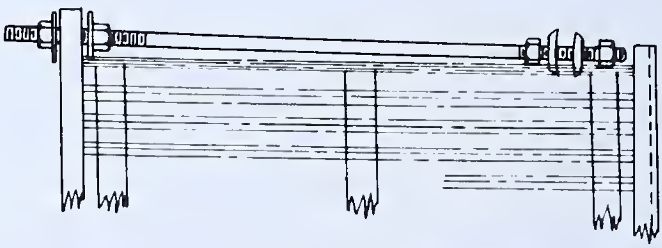


FIG. 480 — *Tie-rods for Securing Mud Drum in Position*

5. Attach the tie bars to steam drum as shown in Fig. 484. (Remove the crane hook.)
6. Attach a pendant (Fig. 482) to the steam outlet *b* on the top of the steam drum, Fig. 479, and carry it around to the front of the drum and attach a chain hoist as shown in Fig. 484.
7. Attach the other end of the chain hoist to a choker drawn through one of the dogs on the downtake section and take up the slack.

FIG. 481 — *Steam Drum Tacked in Place*

8. By manipulating the adjustment on the tie rods and adjusting the chain hoist, level the steam drum fore-and-aft. (Check the position with a level placed on the flange of the steam outlet *b*, Fig. 484.)

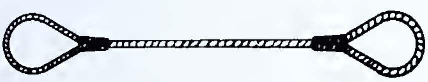


FIG. 482 — *Pendant*

9. By manipulating the special jack adjustment, level the steam drum inboard and outboard. (Check the position with a level placed on the flange of the steam outlet *b*. During the leveling operation, adjust the height of the steam drum to the height given on the blueprint.)

10. Adjust the tie bars to bring the steam drum the correct distance from the face of the uptake headers. See the blueprint.

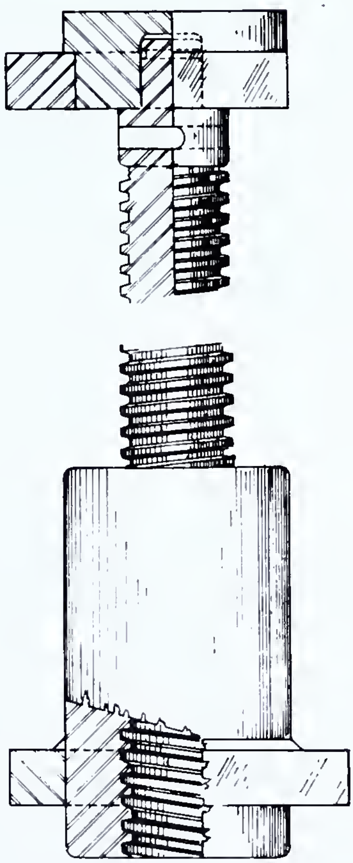


FIG. 483 — *Special Jack*

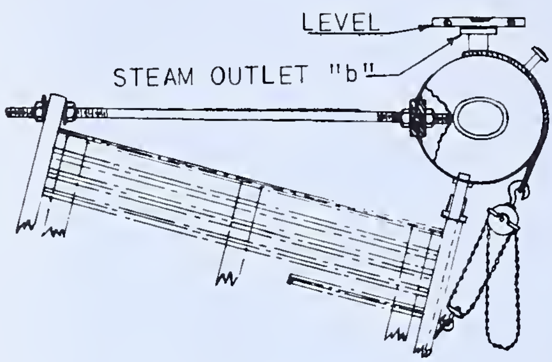


Fig. 484 — *Leveling the Steam Drum*

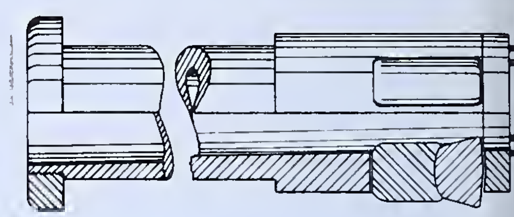


Fig. 485 — *No. 4294 Extension Expander*

11. Check the position of the steam drum to make sure the nipple openings in the bottom side of the steam drum are in alignment with the nipple openings in the top of the downtake headers.

12. Measure for the length of the two end downtake nipples and one center nipple. See Fig. 487 for the correct procedure.

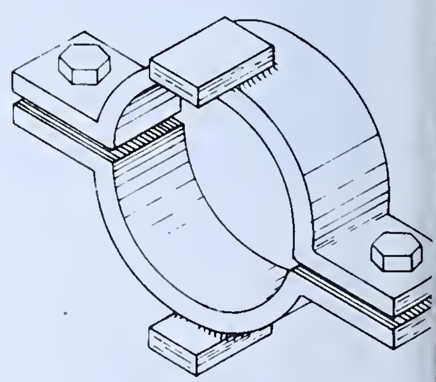


Fig. 486 — *Special Clamp*

13. Measure for the length of the two circulator tubes. See Fig. 491 for the correc procedure.

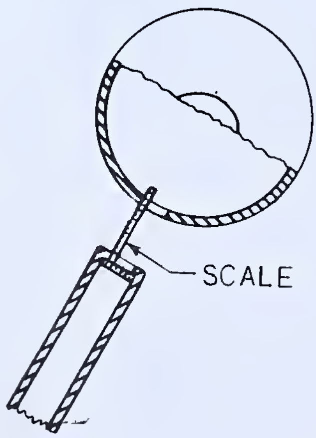


Fig. 487 — *Measuring for the Downtake Nipple Length*

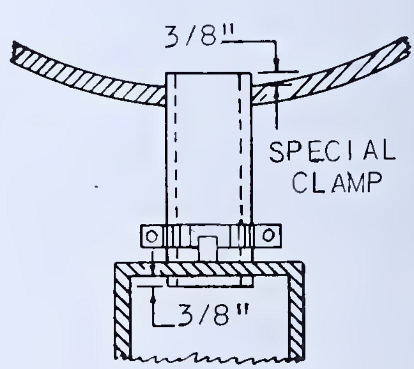


Fig. 488 — *Clamping the Nipples in Place*

14. Have the nipples cut to length in the machine shop, and have the circulator tubes cut to length in the pipe shop.

15. Lower the end downtake nipples through the steam drum and into the tops of the downtake sections. Clamp the nipples in position with special clamp, Fig. 486, as shown in Fig. 488.

16. Insert expander No. 7391 and mandrel No. 44 and expand with No. 5 compound expanding machine. (Always apply tubalube grease to any expander before using.) See Fig. 519 for method of expanding.

17. Replace the mandrel No. 44 with mandrel No. 48 and repeat the operation in Step 16. (This last expanding operation is for the purpose of making a tight joint.) Remove the tube clamp.

18. Remove expander No. 739 and replace with an extension expander No. 4294. See Fig. 485.

19. Assemble No. 60 mandrel, extension coupling, and extension. Insert the assembly in expander No. 4294 and expand bottom of downtake nipple in the downtake header.

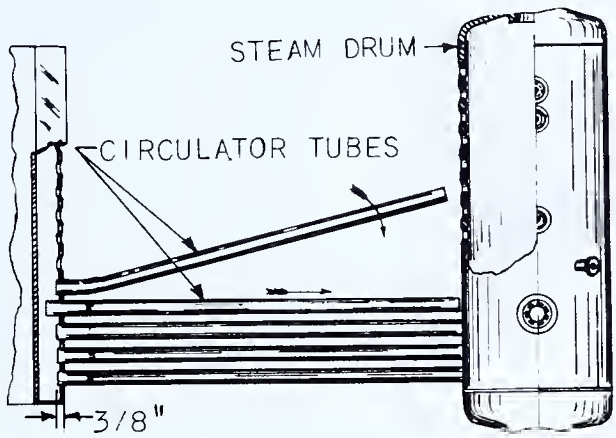


Fig. 489 — *Top View of Circulating Tubes*

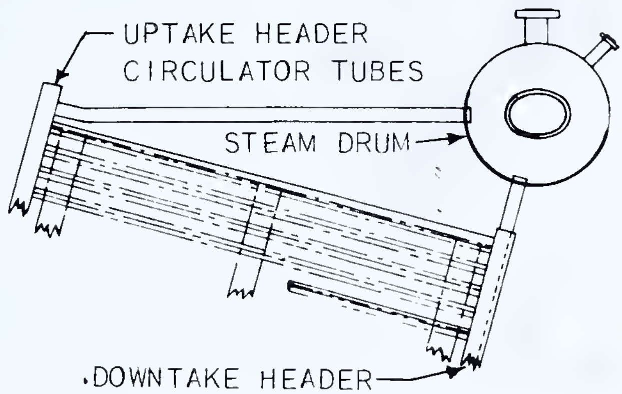


Fig. 490 — *Side View of Circulating Tubes*

20. Remove expander.

21. Expand the other end nipple beginning as in Step 16 and continuing through Step 20. Install a third nipple in the center opening of the steam drum and the top of the downtake section. See Fig. 481.

22. Insert the bent end of the circulator tube in the end opening of the steam drum and the end section of the uptake header. See Fig. 489. Roll the tube from a horizontal position as shown by the arrow. When the tube reaches a position where the straight end is fair with the opening, insert it in the steam drum. See Fig. 490. Figure 491 gives the correct distance the tube projects inside the steam drum.

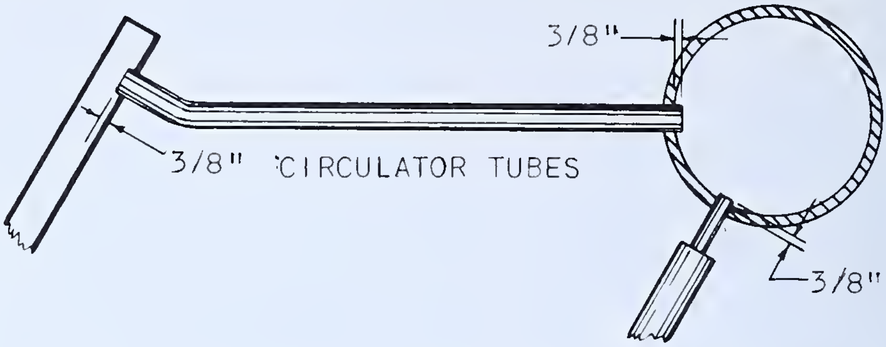


FIG. 491 — *The Circulator Tubes Project into the Uptake Headers and the Steam Drum 3/8"*

23. Place a tube clamp on the circulator tube against the header end.
24. Go inside the steam drum and place expander No. 7397 in the end of the tube.
25. Insert mandrel No. 58 in the expander and expand with No. 5 compound expanding machine.
26. Remove mandrel No. 58 and replace with mandrel No. 62 and repeat the operation in Step 25.
27. Repeat Steps 24 and 26 inclusive with the circulator tube in the opposite end of the steam drum.
28. Remove pipe clamp from header end of circulator tube.
29. Insert expander No. 7392 and mandrel No. 58 in the header end of the circulator tube and expand with No. 5 compound expanding machine.
30. Remove No. 58 mandrel and replace with No. 62 mandrel. Repeat the operation in Step 29.
31. Repeat Steps 28 and 30 inclusive with the circulator tube in the opposite-end header.
32. Remove tie bars, chain hoist, and special jacks.
33. Measure for the length of the remaining downtake nipples and circulator tubes.
34. Have the nipples and tubes cut to length in the machine shop.
35. Install all downtake nipples according to procedure given above.
36. Install all circulator tubes according to procedure given above.

QUESTIONS

1. Why is the steam drum cleaned before it is installed?
2. How is the steam drum held in position prior to expanding tube and nipples?
3. What is the diameter of a downtake nipple?
4. What is the diameter of a circulator tube?
5. Explain the procedure for aligning a steam drum.
6. State the locations of the first tubes expanded.
7. What size of compound expanding machine is used to expand the tubes and nipples?
8. How is a downtake nipple held in position?
9. How is the measurement of the nipple length found?
10. How is the measurement for a circular-tube length found?
11. Which end of the circulator tube is inserted first?

JOB SHEET NO. 27
TO INSTALL REAR WATER WALL

General Information

The rear water wall is installed after the sectional header and the steam drum have been installed. Figure 497 shows the rear water wall in place. Figure 493 shows the types of boiler tubes used in Babcock and Wilcox boilers.

Tools and Equipment

1. Level
2. Ball-peen hammer
3. No. 3 compound tube-expanding machine
4. Expander No. 7368
5. Mandrel No. 40
6. 2 iron wedges
7. Special clamp

Materials

14 T9 Rear water wall tubes

Tubalube grease

Rags

Kerosene

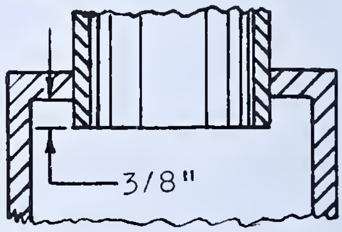


Fig. 492 — *Tube Projects 3/8" into Uptake Header*

Procedure

1. Procure from stores 14 T9 rear water wall tubes. See Fig. 493.
2. Clean the outside of both ends of the tubes, and clean the tube seats in the headers.
3. Line rear wall header 1" lower than the length of the tubes. See blueprint for exact measurement.

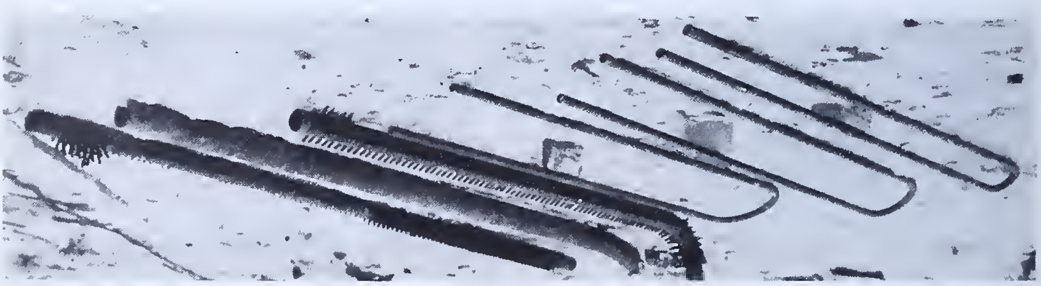


Fig. 493 — *Types of Boiler Tubes (left to right)*

MK.	*No. Req.*	*Size*	*Name*	*Wall Thickness B.W.G.*
T1	73	1¼"	Inner Loop for S. H.	11
T2	73	1¼"	Middle Loop for S. H.	11
T3	73	1¼"	Outer Loop for S. H.	11
T9	14	3¼"	Rear W. W. Tube	6
T13	14	4½"	Circulator Tube	4
T8	22	3¼"	Side W. W. Tube	6

MK. — *Mark*
S.H. — *Superheater*
W.W. — *Water Wall*
B.W.G. — *Birmingham Wire Gage*
A.B. — *Angle Braces*
R.W.W. — *Rear Water Wall*
M.D. — *Mud Drum*

4. Insert the bent end of the rear water wall tube into the hole provided in the bottom of the uptake header as shown in Fig. 495, and at the same time drop the lower end into the opening provided in the rear water wall header.

5. Clamp the bent end of the rear water wall tube to the 2″ generating tube directly above the bend. Use the special clamp shown in Fig. 498. Adjust the clamp to allow the tube to project ⅜″ into the uptake header. See Fig. 492.

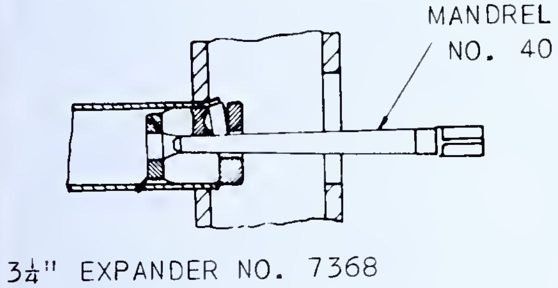


Fig. 494 — *Expanding Rear Water Wall Tube*

6. Insert Expander No. 7368 and Mandrel No. 40 into the bent end of the tube. Insert the expander (Fig. 492) and mandrel through the uptake header from the rear. See Fig. 494.

7. Place the No. 3 compound expanding machine over the end of the mandrel in the tube end and expand the tube.

8. Remove the expanding machine, mandrel, and expander.

9. Remove the special clamp.

10. Proceed to install and expand the other 13 rear water wall tubes in the same manner.

11. Raise rear water wall header to allow the lower ends of the rear water wall tubes to project ⅜″ beyond the inside of the header.

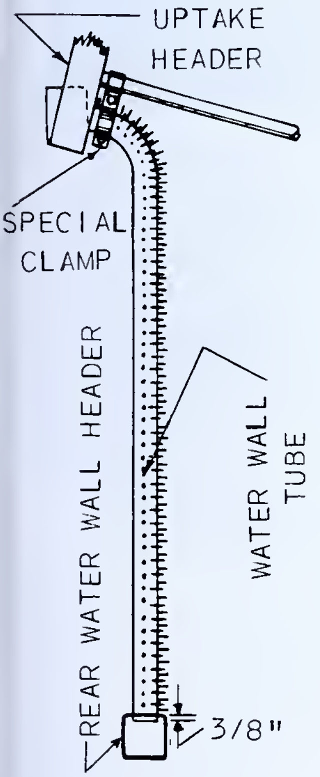


Fig. 495 — *Rear Water Wall Tube*

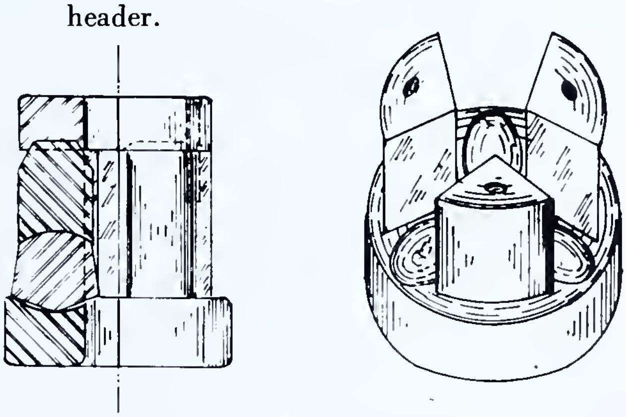


Fig. 496 — *No. 7368 Expander*

FIG. 497 — *Rear View of Boilers Ready for Preliminary Hydrostatic Test*

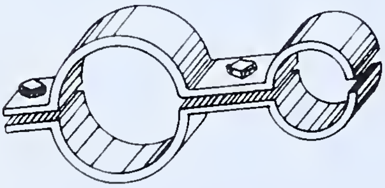


FIG. 498 — *Special Clamp*

12. Check the rear water wall header with the level and adjust it with wedges on both ends until it is level.

13. Insert expander and mandrel used in Step 6 into the first tube through the handhole in the bottom of the rear water wall header at one end of the header. Drive the mandrel into the expander with a light blow of the ball-peen hammer.

14. Attach a $\frac{7}{8}''$ universal and a 12″ extension to the mandrel.

15. Place the No. 3 compounding machine (Fig. 499) over the end of the extension and proceed to expand the tube as in Step 7.

16. Repeat Steps 13 to 15 inclusive at the opposite end of the rear water wall header.

17. Proceed to expand the remaining 12 rear water wall tubes as instructed above.

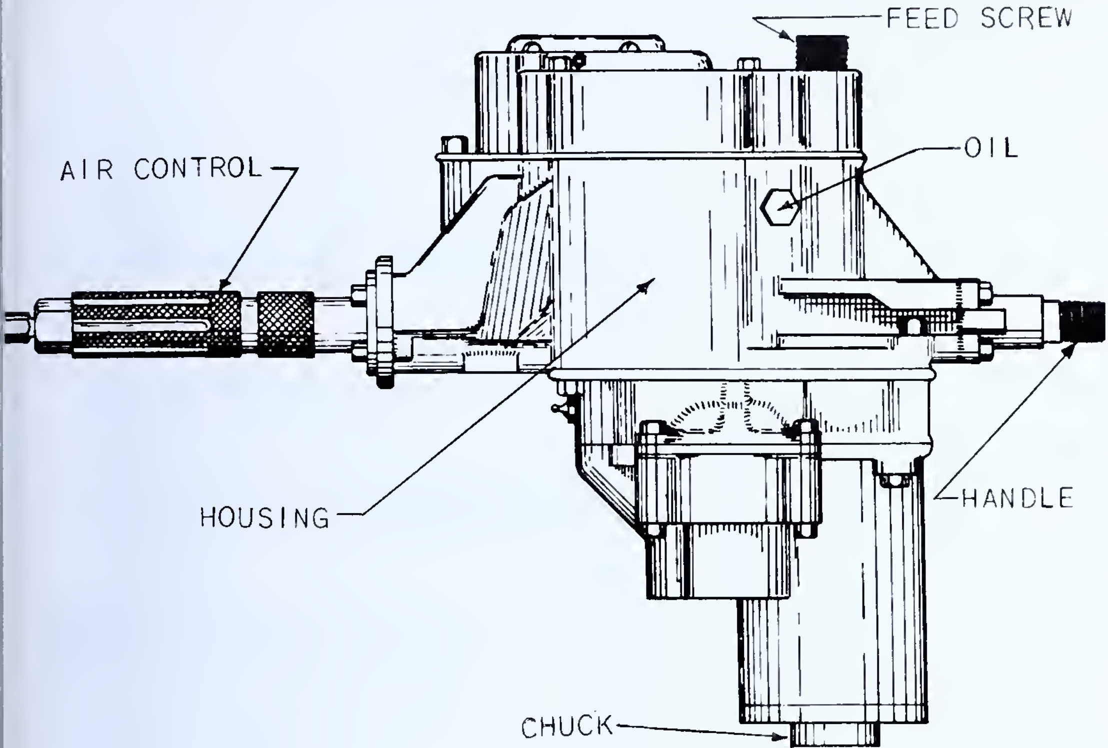
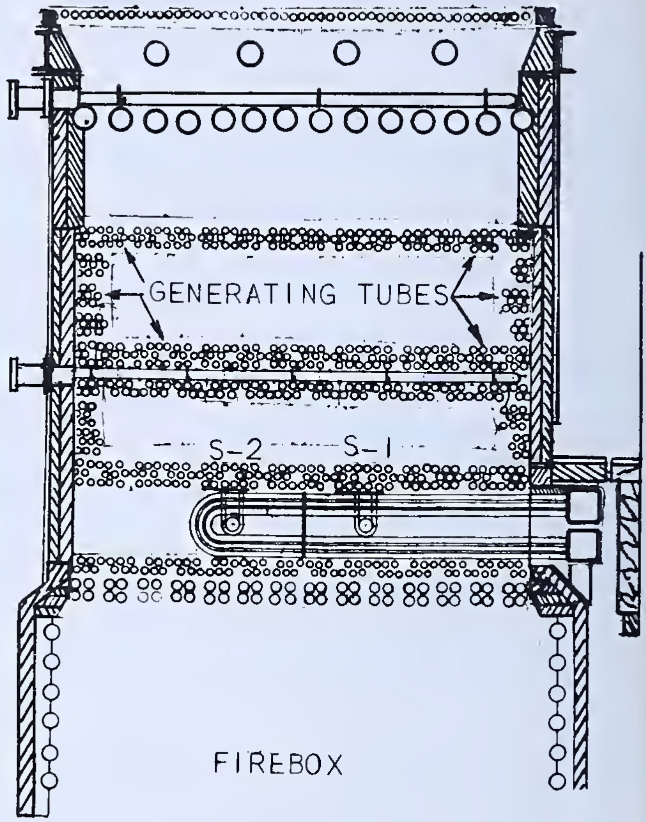


Fig. 499 — *No. 3 Compound Tube-Expanding Machine*

QUESTIONS

1. How many tubes are contained in the rear water wall?
2. Which end of the rear water wall tube is inserted in the uptake header?
3. What is meant by the "projection" of the tube?
4. Explain the method of holding tube in place while it is being expanded.
5. Where is the rear water wall header located?
6. Why is the rear water wall header set 1″ lower while installing the tubes?

JOB SHEET NO. 28
TO INSTALL A SUPERHEATER



General Information

A superheater is necessary for the purpose of raising the temperature of saturated steam to a point where it can be used to drive turbo-electric generators. The superheater unit consists of hairpin tubes which are installed in superheater headers as shown in Fig. 500.

The superheater is located above the firebox as shown in Fig. 501. As the saturated steam leaves the steam drum it is by-passed through the superheater tubes. The heat from the firebox is constantly rising through the tubes above the firebox and of course the temperature of the steam in the superheater tubes is raised very considerably. The superheated steam goes from the superheater into the main steam line.

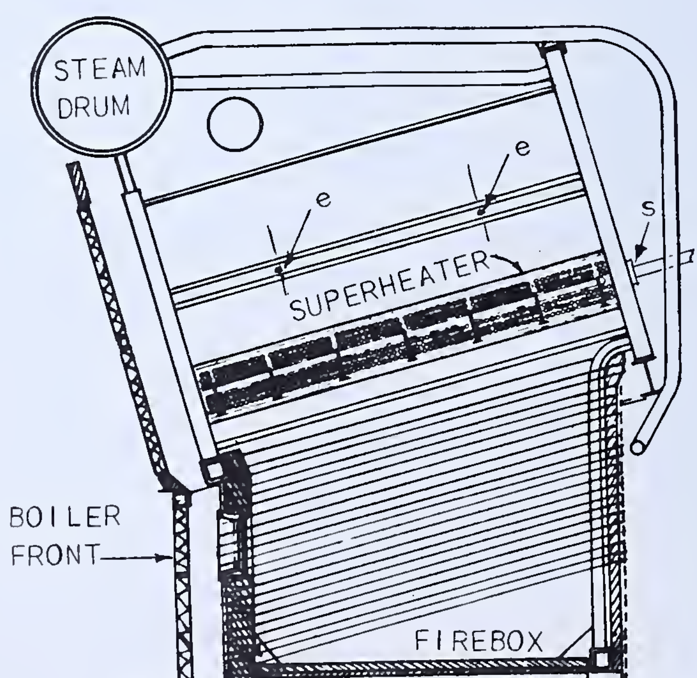


Fig. 501 — *Superheater Above Firebox*

Tools and Equipment

1. 1 Expander No. 7249
2. 1 Mandrel No. 15
3. 1 Mandrel No. 17
4. 1 Mandrel No. 19
5. 1 Black Hawk extension
6. 1 Black Hawk universal expanding machine
7. 1 No. 2 Compound tube expanding machine
8. 6 Iron wedges
9. Ball-peen hammer
10. 1 Expander No. 7243
11. 1 Expander No. 7249
12. 1 Wedge bar
13. 2—12″ Wooden wedges
14. 2 Dialoy soot blower elements No. 2
15. 2 Dialoy soot blower seals
16. 48—3/8″ x 1″ tap bolts

Materials

73 T1 Tubes
73 T2 Tubes
73 T3 Tubes
Shims shown on blueprint
2—7-B-22
2—7-B-24
4—7/8″ standard washers
Rags
Kerosene
Emery cloth
Tubalube grease
7 Soot blower bearings FM-7040
14 U-bolts FM-4253
2 Dialoy soot blower elements No. 1

Procedure

1. Install soot blower bearings, Fig. 502, for element S1 shown in Fig. 500. Make certain that nuts are tight on U-bolts, Fig. 502 at *a*.

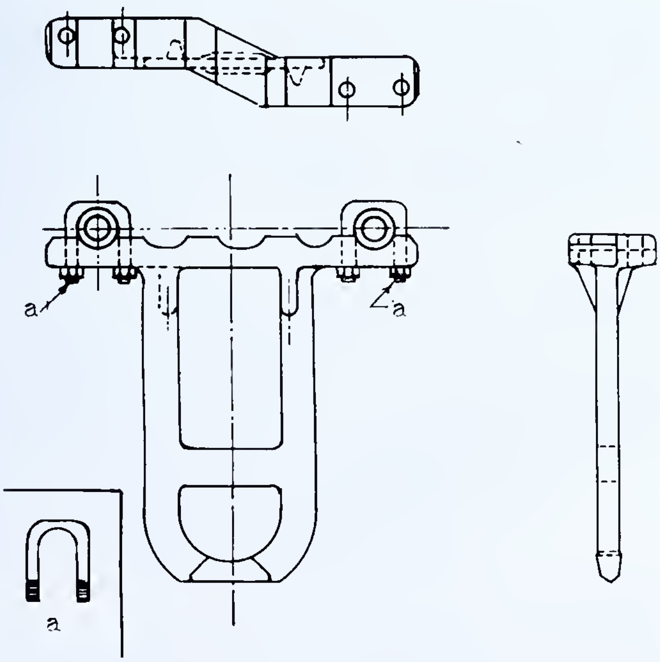


Fig. 502 — *Soot Blower Bearing*

2. Install support plates, Fig. 503, between superheater support tubes in Fig. 504, at *a*.

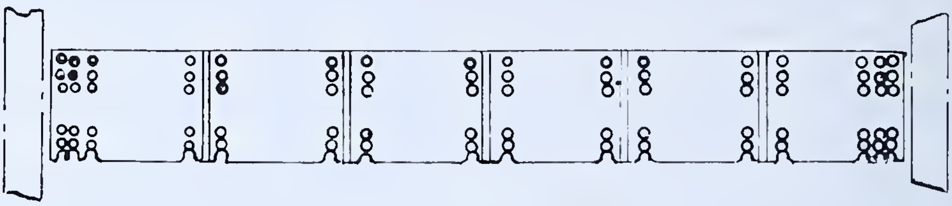


FIG. 503 — *Support Plates*

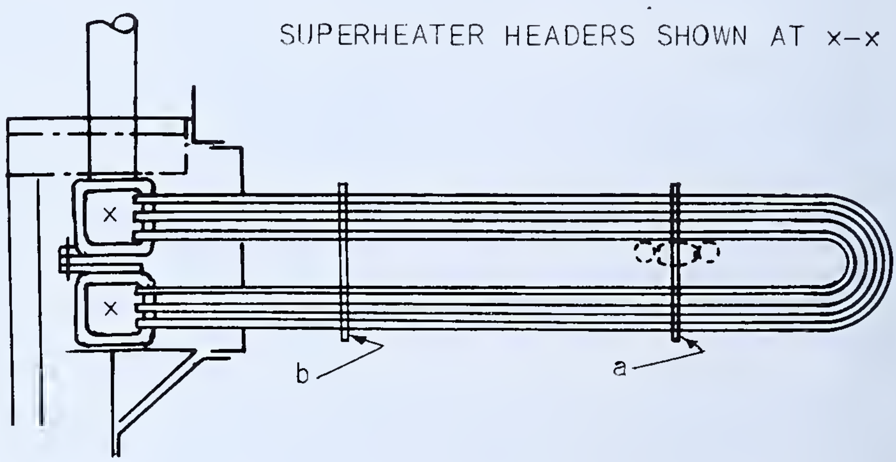


FIG. 504 — *Support Plates* a *and Protection Plates* b

3. Install protection plates, Fig. 505, on outboard side of boiler between uptake and downtake headers as shown in Fig. 504 at *b*. Use 3/8″ tap-bolts to hold plates in position.

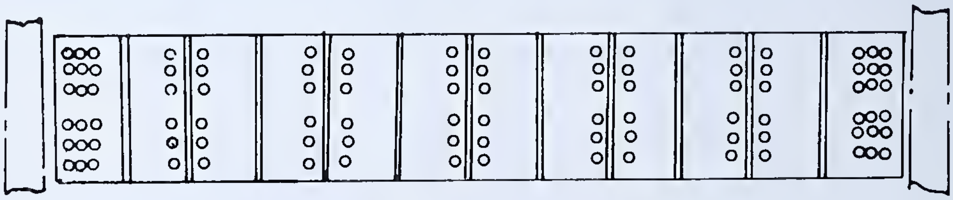


FIG. 505 — *Protection Plate*

4. Install soot blower bearings, Fig. 502, for element S2 shown in Fig. 500. Make certain that nuts are tight in U-bolts.

5. Thread T-1 tubes through support plates and protection plates as shown in Fig. 500, Fig. 506, and Fig. 507.

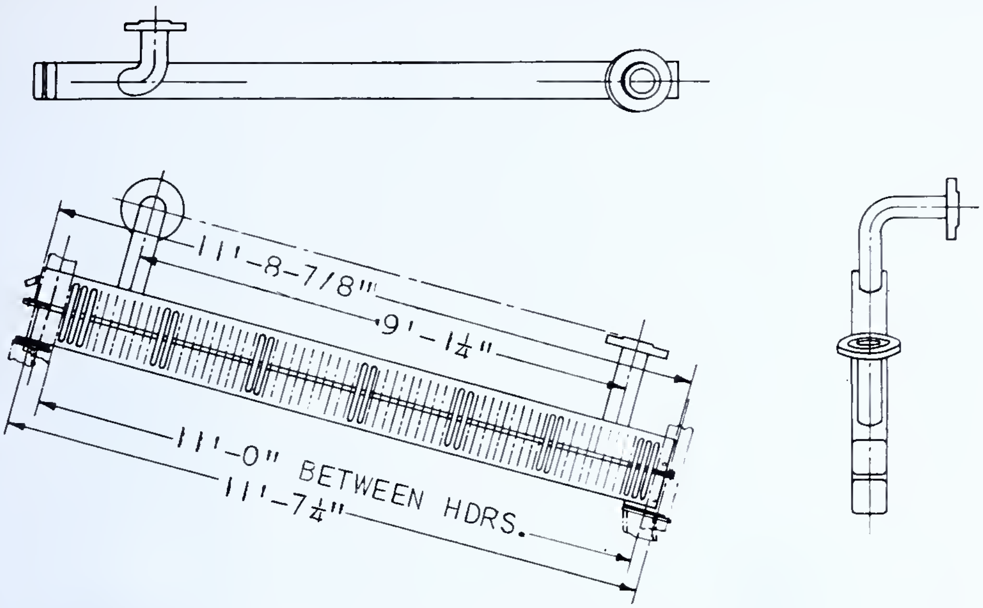


Fig. 506 — *Superheater Headers*

Fig. 507 — *Setting and Aligning a Superheater*

6. Thread T-3 tubes through support plates and protection plates at the same locations as in Step 5.

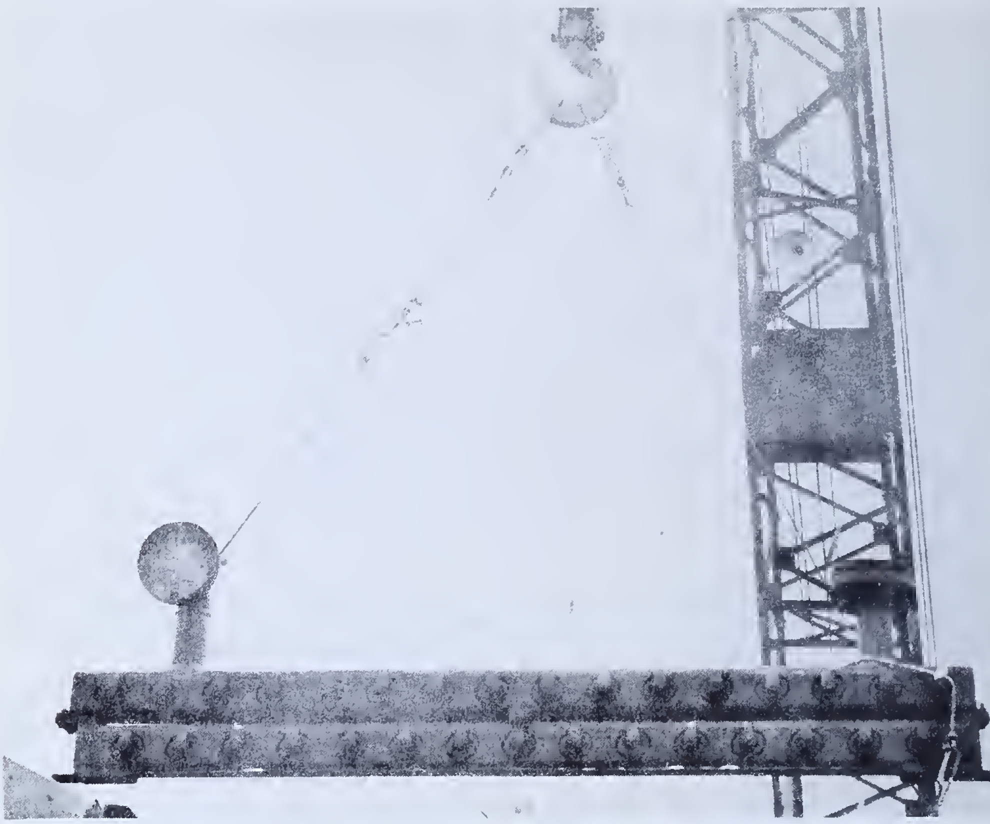


FIG. 508 — *A Superheater Header*

7. Clean thoroughly the superheater header, Fig. 508.
8. Install superheater headers as shown in Fig. 506. See details Fig. 509 and Fig. 510 for location of bolts and shims.
9. Shim the superheater headers up to a level which will bring the openings in the headers in line with the ends of the T-1 and T-3 tubes as shown in Fig. 500.
10. Install soot blower seal as shown in Fig. 501 at *s*.

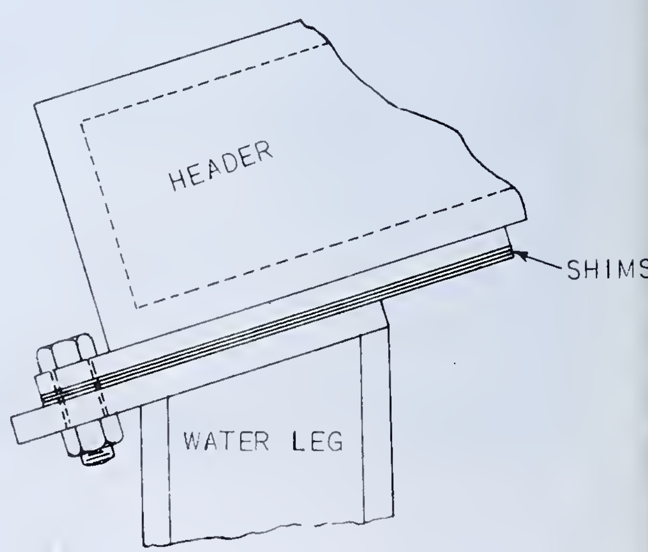


FIG. 509 — *Front End of Superheater Header*

11. Install dialoy soot blower elements No. 1 and No. 2 as shown in Fig. 501 at *e*.
12. Clean thoroughly the ends of the 57 T-1 tubes.
13. Thread these 57 T-1 tubes through support plates and protection plates and into header as shown in Fig. 500.
14. Set T-1 tubes in upper header as shown in Fig. 512. The ends of the tubes project ¼″ beyond the inside wall of the header. See Fig. 504 at *x*.

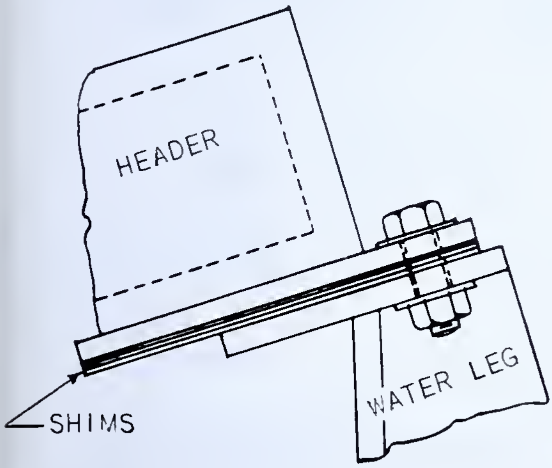


Fig. 510 — *Rear End of Superheater Header*

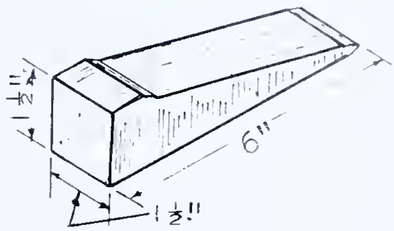


Fig. 511 — *Iron Wedge*

15. Place an iron wedge, Fig. 511, between every pair of T-1 tubes as shown in Fig. 512. (The wedges between the tubes hold them firmly in position while the ends are being expanded. Tap the wedges in with a hammer to make them secure.)

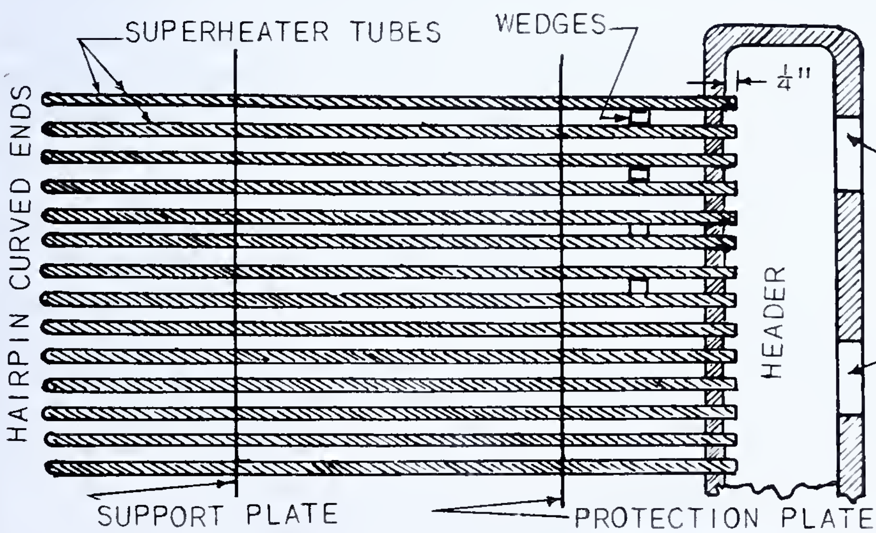


Fig. 512 — *Wedges Between Tubes to Hold Them in Position Until Expanded*

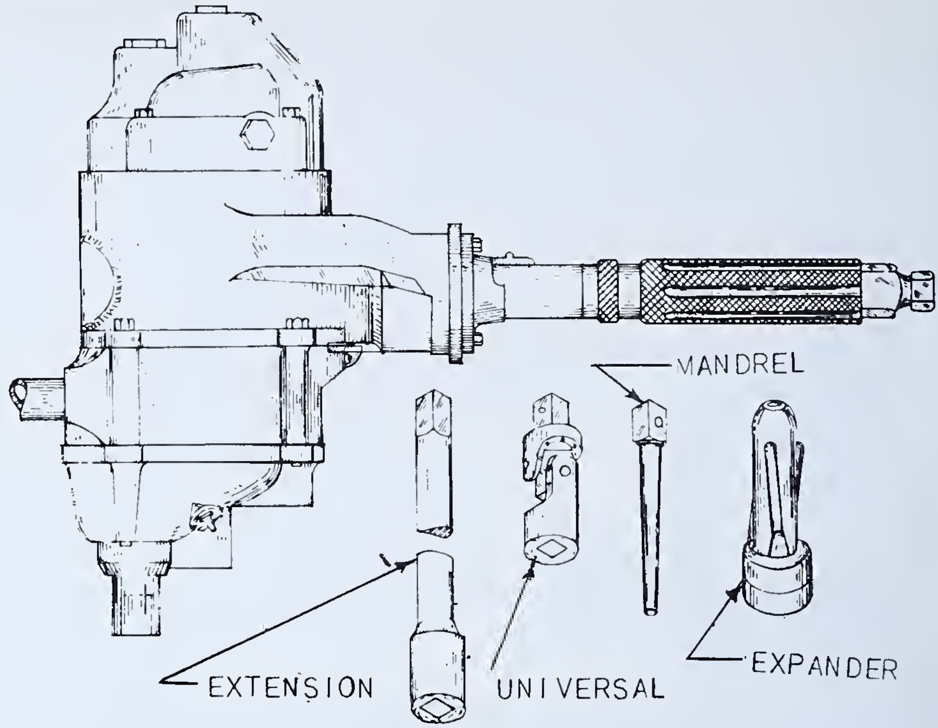


FIG. 513 — *Expander No. 7249 and Accessories*

16. Insert expander No. 7249 and mandrel No. 15 into the end of the first T-1 tube and expand the tube. See Fig. 514 and Fig. 513.

    Use a universal, an extension, and a No. 2 compound tube-expanding machine for this job. Do not "ride" the end of the tube with the expander. As the gauge of the tubes is not uniform, it may be necessary to use successively expanders No. 7243 and mandrels No. 17 and No. 19, after using expander No. 7249 and mandrel No. 15.

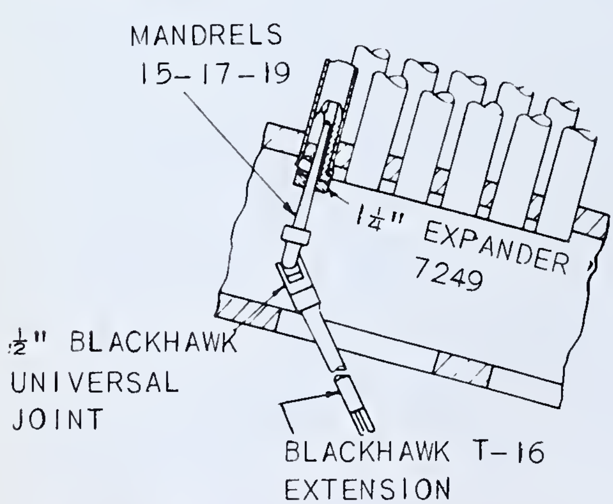


FIG. 514 — *Expanding Superheater Tubes*

17. Proceed to expand the balanc of the tubes in the upper header

    Move the wedges in Step 1 to the next group of tubes as th work requires.

18. Proceed to expand the tubes i the lower header.

    Each tube is treated separately The tubes must be raised o lowered at the hairpin-loop en of the tube. See Fig. 515. Th raising or lowering of the tube will bring the end to be expande ¼" beyond the inside wall of th header. See Fig. 515 at *b*. Th raising or lowering of the tub

end is accomplished by inserting the wedge bar between the T-1 tubes and the generating tubes. A slight pressure up or down with the wedge bar will bring the T-1 tube to the required location.

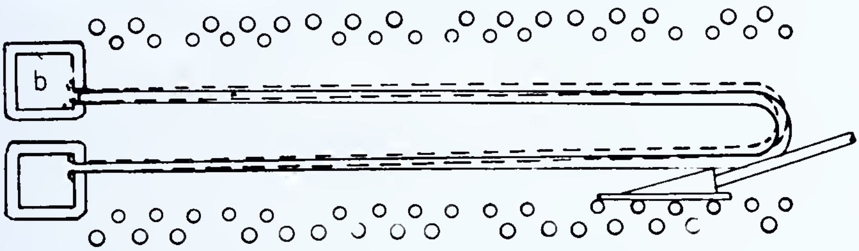


FIG. 515 — *Adjusting Superheater Coils Level*

19. Follow the same procedure with the installation of the T-2 and T-3 tubes beginning with Step 12 and following through to Step 18.

QUESTIONS

1. **What is the purpose of a superheater?**
2. **On which tubes are the soot blower bearings installed?**
3. **What kind of metal is used in No. 1 and No. 2 soot blower elements?**
4. **Why are shims used below the superheater header?**
5. **Why are the iron wedges used between certain tubes during the expanding operation?**
6. **Explain the sequence of expanding a T-1 tube.**
7. **Why is it not permissible to "ride" the end of a tube?**
8. **Why is it necessary to use different size expanders and mandrels?**
9. **How is the correct projection of the superheater tubes in the lower header obtained?**

JOB SHEET NO. 29

TO INSTALL RISERS AND DOWNCOMER TUBES

General Information

Downcomer tubes are installed between the lower half of the steam drum and the front-corner boxes. The feedwater passes from the lower half of the steam drum through the tubes and into the front-corner boxes and on into the side water walls.

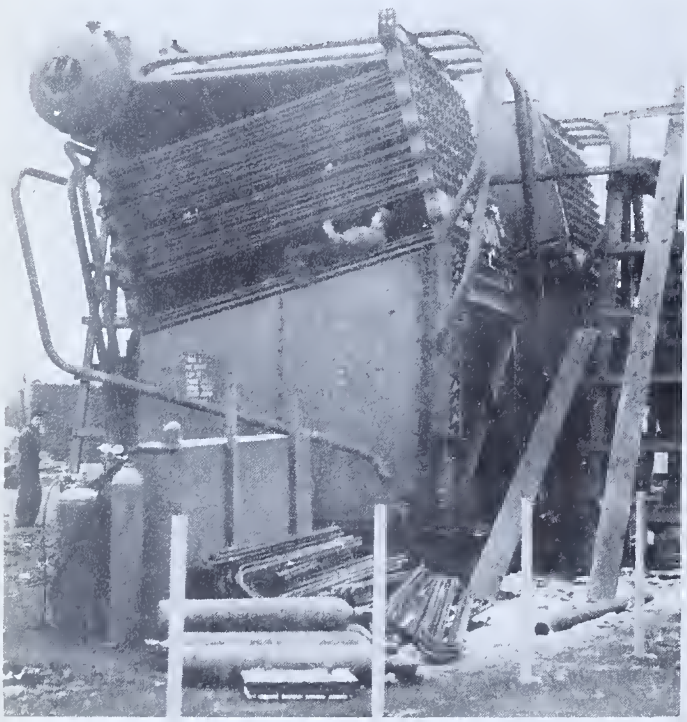


Fig. 516 — *Side View of Boilers Ready for Hydrostatic Test. Note Side Casing Removed for the Purpose of Finding Leaking Tubes*

Risers are installed between the rear-corner boxes and the upper half of the steam drum. The water from the side water walls has by this time been raised to a temperature closely approximating the boiling point. It rises through the rear-corner boxes into the riser tubes and on into the steam drum. The arrangement and position of these tubes are shown in Fig. 516.

The rear view of the installation is shown in Fig. 518. The side view is shown in Fig. 520. The front view is shown in Fig. 521.

Safety

The erection of the boiler has now progressed to a point where many other operations and jobs are going on at the same time. Care must be taken to avoid dropping tools and equipment that could cause injuries to other workmen.

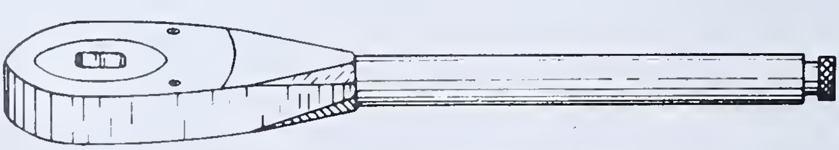


Fig. 517 — *No. 3 Ratchet Wrench*

Tools and Equipment

1. Expander No. 7397, Fig. 519
2. Mandrels No. 58 and No. 62, Fig. 519
3. Expander No. 7392, Fig. 522
4. Mandrels Nos. 58, 62, 66 and 70, Fig. 522
5. No. 3 ratchet wrench, Fig. 517
6. Ball-peen hammer
7. No. 5 compound tube-expanding machine
8. Folding rule
9. Choker
10. Chain hoist
11. Special clamp, Fig. 486

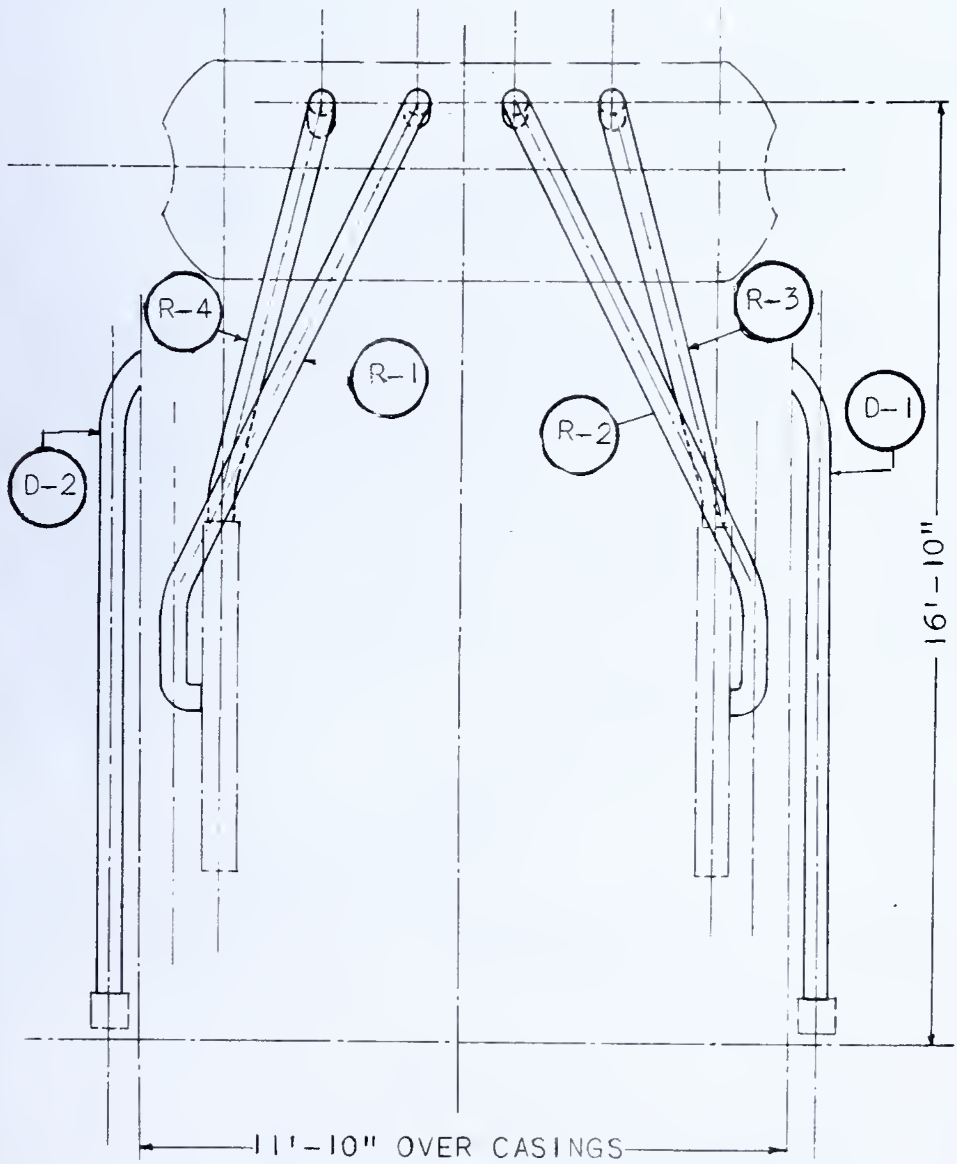


Fig. 518 — *Risers and Downcomers as Seen from the Rear of the Boiler*

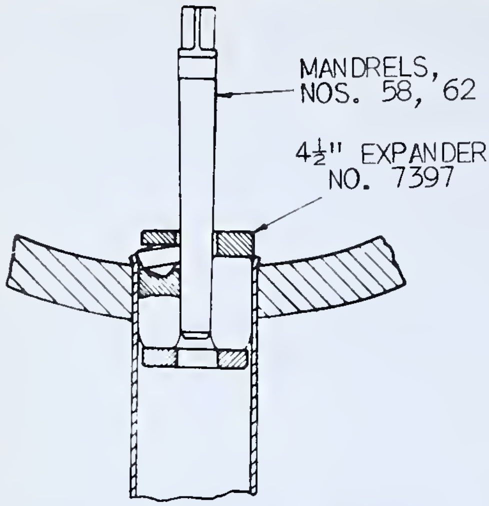


Fig. 519 — *Expanding Tube End in Steam Drum*

Materials

1—4½″ tube pc. mk. R1
1—4½″ tube pc. mk. R2
1—4½″ tube pc. mk. R3
1—4½″ tube pc. mk. R4
1—4½″ tube pc. mk. D1
1—4½″ tube pc. mk. D2
1—4½″ tube pc. mk. D3
1—4½″ tube pc. mk. D4
1—4½″ tube pc. mk. D5
1—4½″ tube pc. mk. D6
Tubalube grease

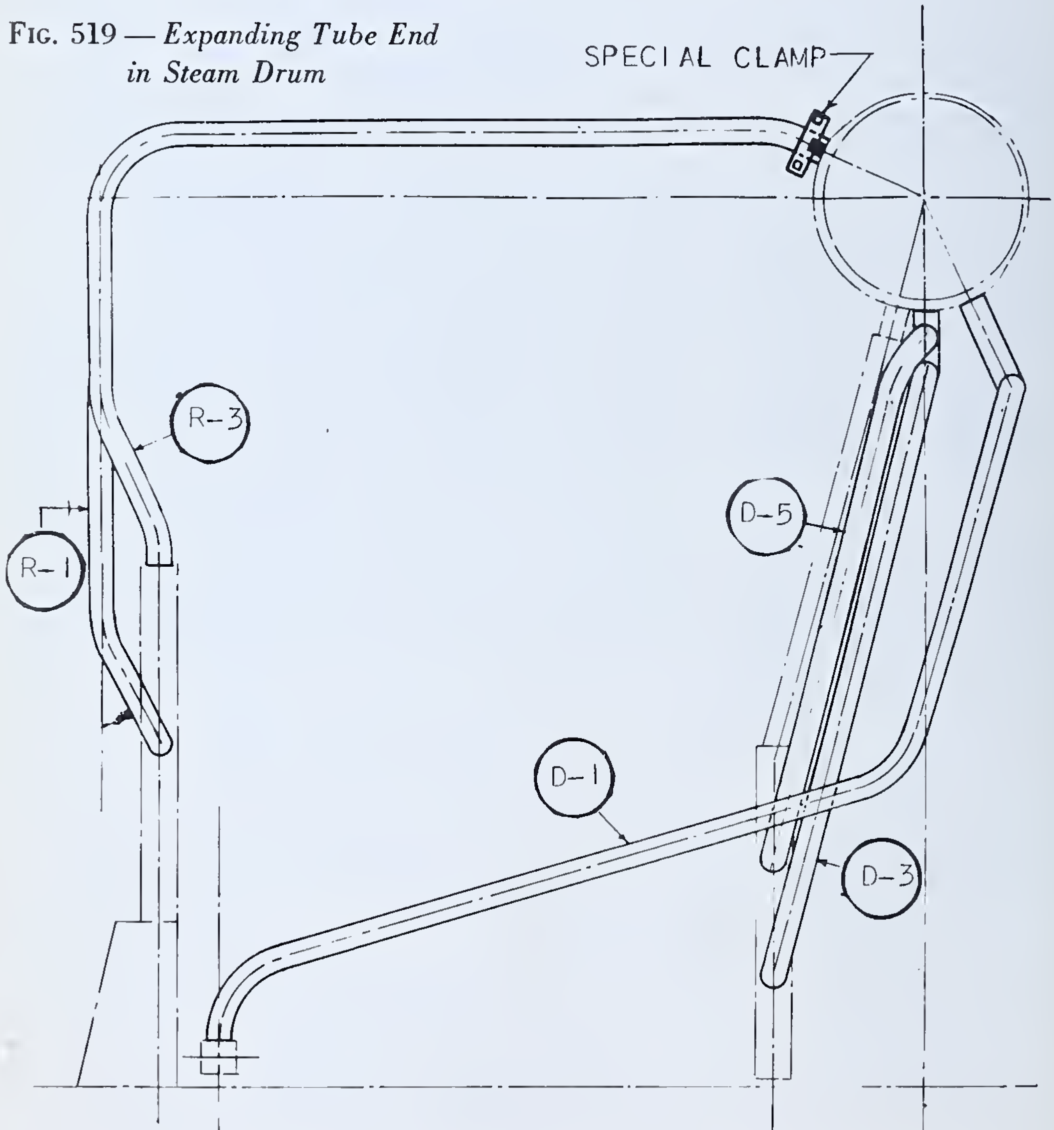


Fig. 520 — *Risers and Downcomers as Seen from the Side of the Boiler*

PROCEDURE

To install tubes R-1, R-2, R-3 and R-4 as shown in Figs. 518 and 520.

1. Insert the tube upper ends in the openings provided in the steam drum, and the lower ends in the rear-corner boxes. Begin at either end of the steam drum.
2. Place special clamp shown in Fig. 486 around the riser tube as shown in Fig. 520 to allow the tube-end to project 3/8″ beyond the inside of the steam drum.
3. Expand the tube as shown in Fig. 519.
4. Expand the upper ends of the other three tubes in the same manner.
5. Insert expander No. 7392 through the handhole provided in the rear-corner box and into tube R-3 lower end.

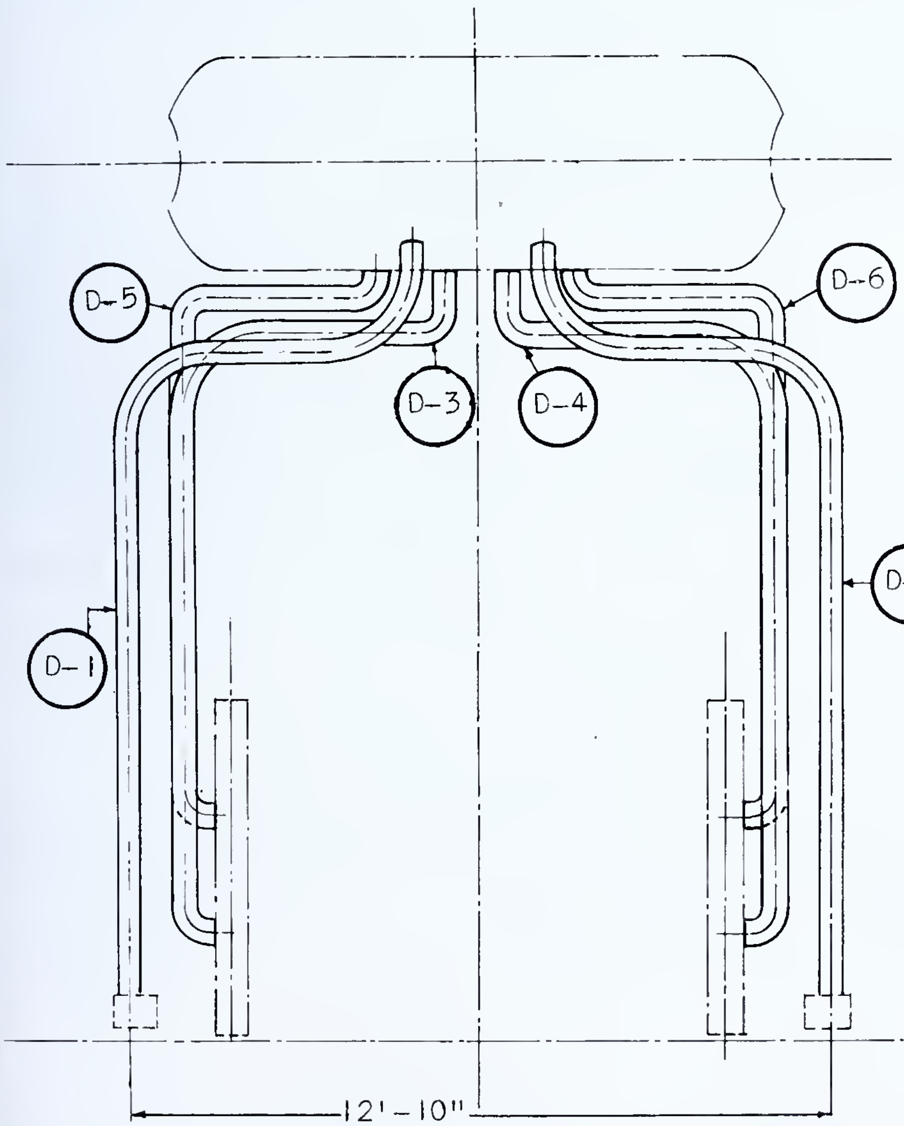


FIG. 521 — *Risers and Downcomers as Seen from the Front of the Boiler*

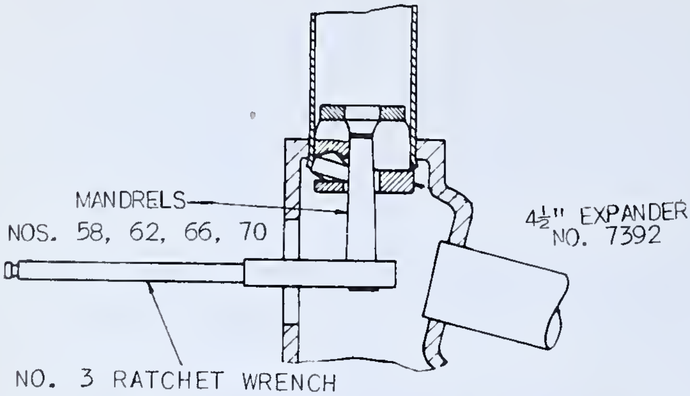


Fig. 522 — *Expanding Tube End in Corner Box*

6. Insert mandrel No. 58 and attach No. 3 ratchet wrench as shown in Fig. 522.
7. Operate the expander in a clockwise direction and expand the tube.
8. Expand tube R-4 in the same manner.
9. Expand tubes R-1 and R-2 in a similar manner, but with expander inserted in a horizontal position as shown in Fig. 523.

To install tubes D-5 and D-6 as shown in Fig. 521 and Fig. 520.

1. Hang the chain hoist from the upper side of the steam drum above the position of the downcomer tube as shown in Fig. 521.

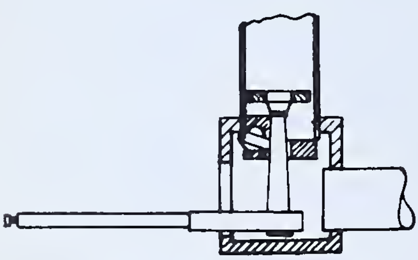


Fig. 523 — *Expanding Tubes R-1 and R-2*

2. Hook the chain hoist on to a choker which is placed around the upper end of the downcomer tube.
3. Raise the tube until the tube end projects 3/8" beyond the inside of the steam drum.
4. Expand the tube as shown in Fig. 519.
5. Raise and expand tube D-6 in the same manner.
6. Raise and expand tubes D-3 and D-4 in the same manner.
7. Raise and expand tubes D-1 and D-2 in the same manner.
8. Insert expander No. 7392 through the handhole provided in the front-corner box and into the lower end of D-5.
9. Insert mandrel No. 58 and attach No. 3 ratchet wrench.
10. Operate the expander in a clockwise direction and expand the tube.
11. Expand the lower ends of tubes D-3, D-4, and D-6 in the same manner.
12. Insert expander No. 7392 through the handhole provided in the rear water wall header and into the lower end of tube D-1.
13. Expand the tube following the procedure in Step 8 through Step 10.
14. Expand tube D-2 in the same manner.

QUESTIONS

1. What are the purposes of riser and downcomer tubes?
2. What is the distance between the center line of the front-corner box and the center line of tube D-5?
3. What is the distance between the horizontal center line of the steam drum and tube R-3?
4. What is the projection of the riser and downcomer tubes?
5. What tools are used to expand the tubes into the corner boxes?
6. How clean should the end of a tube be before it is installed in a tube sheet?

JOB SHEET NO. 30

TO MAKE A PRELIMINARY HYDROSTATIC TEST

General Information

When the erection of the boiler has progressed to the stage outlined in Job Sheet No. 17, a test for leaks is made. Since the brick installation and boiler casing follow the work that has been completed so far, it is necessary at this point to detect and eliminate any leaks because they could not easily be found and repaired if they were covered up.

All boiler tubes with the exception of the sections shown in Fig. 465 and the side water wall shown in Fig. 455 are expanded on the job as the erection proceeds. These sections and side water walls are purchased with the tubes already expanded therein. Rough handling in shipment from the factory to the shop, and rough handling of the sections on the job, however, may cause leaks to develop. Before further work is done on erection of the boiler, all leaks must be found and repaired.

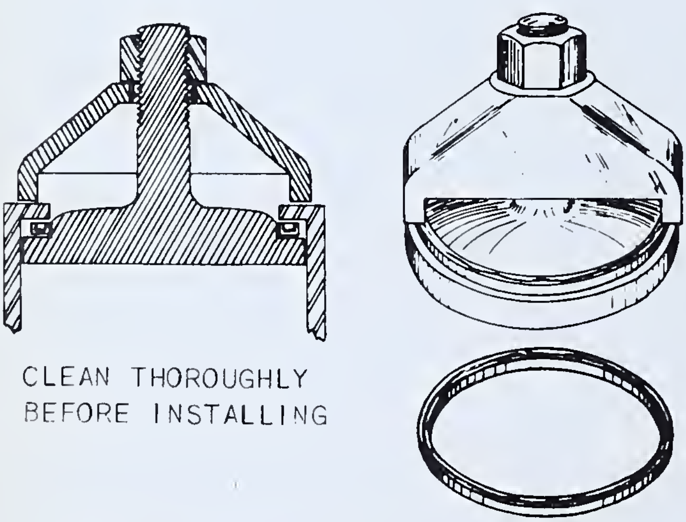


Fig. 524 — *Hand-Hole Cap and Gasket*

Preparing for the Test

The operations that have been explained in Job Sheets No. 11 to No. 17 are all completed, the handhole caps (Fig. 524) are installed, the steam-drum manhole covers are installed, and the steam-drum nozzles are "blanked-off" ("blanked-off" means to bolt a blank plate and a gasket across the openings to make them watertight) before making the test.

Making the Test

The pipefitters under the supervision of the boilermakers make the necessary pipe connections for conducting the test. A pressure gauge and a vent are installed in a steam drum in the two threaded openings provided. A water connection is made at the blowdown. Drain pipes are installed in the bottoms of the water legs, in the rear water wall, and in the superheater header.

Tools and Equipment

1. Expanding equipment which was used in preceding instruction sheets
2. Flashlight

Materials

Tubalube grease
Chalk
Gaskets

Reference—Drawing 525 is in an envelope at the back of this manual. Take it out and use it as a reference for the study of this job sheet.

Procedure for Making the Test

1. Apply water pressure.
   Water is forced into the boiler until it reaches 500 pounds pressure. The boilermaker supervises the operation. If there are any leaks they begin to show as the pressure increases. When a leak becomes evident, the joint is marked with a piece of carpenter's chalk. As the pressure rises, other leaks may show; they are also marked with chalk.
2. Inspect for leaks.
   The points at which leaks are most likely to show are marked by letters in Drawing No. 525. In that numerous leaks may appear before a pressure of 500 pounds is reached, the boiler is usually drained and the leaks that have developed thus far are repaired. It may be that very few leaks will appear up to 500 pounds pressure. In this case, the boiler needs to be drained but once before making repairs.
3. Drain the boiler.
   Open the vents to allow the boiler to drain thoroughly.
4. Remove handhole covers to provide access to the leaking points.
5. Expand the tubes that have been marked with chalk.
   The same expanders and mandrels that were first used at these points are used again. See Drawing No. 525. Locations are marked with reference letters.
6. Replace handhole caps (use new gaskets where necessary).
7. Repeat the test.
   This procedure is followed until all leaks have been located and repaired. The testing operations may continue for several days, but until every leak has been discovered and repaired no further erection work on the boiler is allowed to proceed.

QUESTIONS

1. What is the purpose of a preliminary hydrostatic test?
2. What is the highest pressure reached when making a preliminary test?
3. Explain the method of finding and marking the leaks.
4. Why is it necessary to vent the superheater?
5. Why is it necessary to vent the steam drum?
6. Where do most of the leaks usually occur?

JOB SHEET NO. 31
TO CALK STEAM GENERATING SECTIONS

General Information

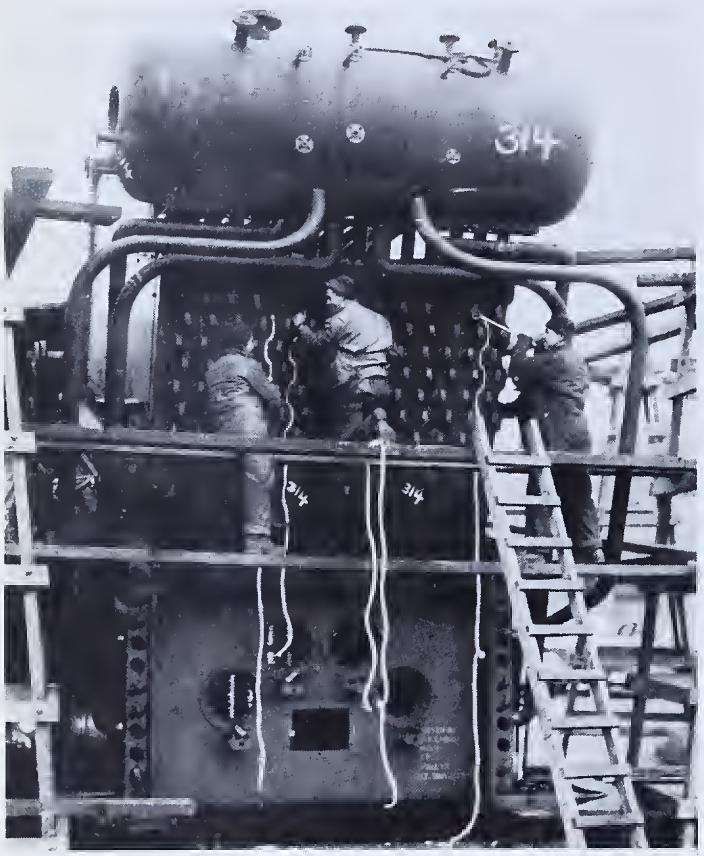


Fig. 526 — *Method of Calking Asbestos Rope Between Sections and Method of Tightening Handhole Caps*

Calking is the term applied to the operation of packing some sort of material tightly into an open space between two surfaces, or edges. The seams in matched flooring are said to be calked if strips of oakum are laid in the space between the flooring strips and driven in tightly.

The spaces between the headers (uptake and downtake) are in appearance much the same as the seams in matched flooring. These spaces must be calked (See Fig. 526) with some kind of fireproof material. Since the hot gases from the burning fuel oil would filter through these spaces, fill the area between the headers and the air casing, and thus create a condition that would prevent regulating the air temperature at the burners. It is imperative that all of these spaces be permanently sealed.

Asbestos rope and a hand-calking tool (Fig. 527) are used for this job. See Fig. 528.

Three strands of ¾″ asbestos rope are used in each space. After the first two strands are "calked-in," a layer of aertite (paste-like substance) is applied in the space with a wooden spatula (stick) to insure a perfect seal. The third strand of asbestos rope is then "calked-in," and another application of aertite is smoothed over the outside. See Fig. 529.

Tightening Handhole Caps

The operation of tightening the handhole caps may be performed either before or after the calking operation. After the preliminary hydrostatic test is finished, the

handhole caps are permanently tightened. See Fig. 526. Use a one-inch six-point or twelve-point box wrench to tighten the handhole caps.

FIG. 527 — *Hand Calking Tool*

FIG. 528 — *Calking by Hand*

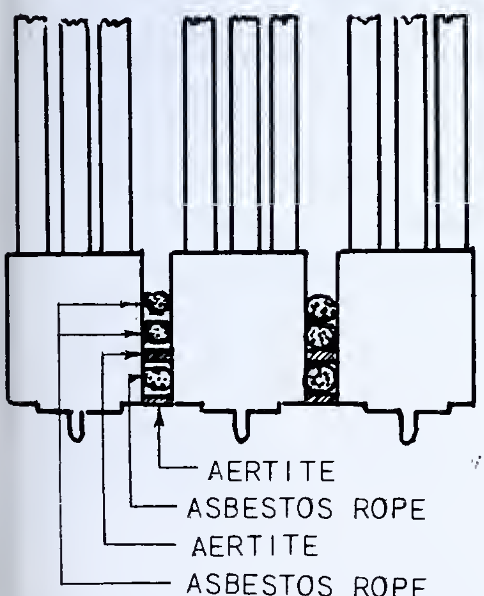


FIG. 529 — *Calking the Space Between Headers*

TOOLS AND EQUIPMENT

1. Calking tool
2. 1½-lb. ball-peen hammer
3. 1″ box wrench
4. Wooden spatula

MATERIALS

¾″ Asbestos rope
Aertite

PROCEDURE

1. Obtain a box of asbestos rope and a bucket of aertite from the store room.
2. Measure the length of the space to be calked.

Carry the end of a strand of rope to the top of the space to be calked. With

the end of the strand held firmly in the space, press it lightly into the opening and follow downward hand-under-hand until the bottom of the space is reached Cut off the strand even at the bottom of the header.

Use this piece to measure and cut the remainder of the rope into similar lengths

3. Start at the top of the center space and calk-in the asbestos rope from top t bottom.

   Drive the rope in to a depth of $1\frac{1}{2}''$. This is about far enough to allow fo two more strands and the aertite. The rope compresses as it is calked, and thre layers of $\frac{3}{4}''$ rope will just about fill the $1\frac{1}{2}''$ depth. See Fig. 528 for the correc manner of holding the calking tool.

4. Calk-in the first strand in the other twelve spaces, working from the center spac both ways.
5. Start at the top of the center space and calk-in the second strand.
6. Continue both ways from the center as in Step 3 and calk-in the second strand.
7. Apply aertite to the second strand in all of the spaces.

   A layer $\frac{1}{8}''$ thick is about right.

8. Start at the top of the center space and calk-in the third strand.
9. Continue both ways from the center space as in Step 3 and calk-in the thir strand.
10. Apply a layer of aertite flush with the headers over all of the strands.

    The rear sectional headers are calked-in in the same manner as outlined abov Return any surplus material to the storeroom.

QUESTIONS

1. **What is understood by the term calking?**
2. **State the location of the calking job outlined in this instruction sheet.**
3. **What is the purpose of calking?**
4. **How is the length of a strand determined?**
5. **How many strands are used in a space?**
6. **Why is it important that the aertite be applied?**
7. **Why is the calking tool held in the position shown in Fig. 528?**

JOB SHEET NO. 32
TO ERECT FRONT AIR CASING

General Information

The air casing forms an airtight passage from the air heater to the burners to accommodate the preheated, forced-draft hot air which aids combustion. The air casing permits access to the downtake sections for inspecting, cleaning, and repairing and also keeps the hot air in the boiler from escaping to the boiler room. It is important to have air casing erected in strict accordance with the drawings and to have all the adjoining pieces of casing and joints absolutely airtight. Where a packing strip cannot be used in the joints, they should be made tight with Fenox (sealing compound).

No casing should be cut with a burning torch until all methods of erection have been tried. Burning one piece of casing to make it fit right may throw the remaining parts of the casing out of alignment. Most of the casing can be erected with little or no trouble. Use a drift pin and a hammer to bring the holes in adjoining pieces into correct alignment. No allowance in measurements is made for the packing strip. An iron wedge inserted between two adjoining flanges will be sufficient to permit entrance of the packing strip. Holes that cannot be aligned by drifting must be reamed.

Reference—Drawings 530, 531, and 532 are in the back of this manual. Use them as a reference for the study of this job sheet.

Tools and Equipment

1. 1—½-lb. ball-peen hammer
2. ⅜″ drift pins
3. ⅛″ drift pins
4. Iron wedges
5. ⅜″ spud wrench
6. ⅞″ reamer
7. ½″ spud wrench
8. 9/16″ reamer
9. No. 1 drilling machine
10. Six-foot folding rule

Materials

Brass-bound asbestos packing strips.

Sealing compound (Fenox)

Procedure

1. Insert six ½″ stud bolts (Drawing No. 530 at *T*) into inner front plate.
2. Place bladed cone *D*, shown in Drawing No. 530, over the studs on the outside of the inner front plate and pull the nuts up tightly.
3. Place three grids over the studs on the furnace side of the inner front plate and pull the nuts up tightly.

   Install three other sets of bladed cones and grids in a similar manner.
4. Install four drains *A* into the four riders, pc. mk. B-58988, shown in Fig. 533, and bolt into place as shown at *C*.

5. Place ½″ asbestos board in front of downtake nipples as shown in Drawing No. 532, at section *A-A*.
6. Place pc. mk. (piece mark) T-S-25, shown in Drawing No. 532, at section *A-A*, using 6—3-T-B-25 to bolt in position.
7. Using 33—3-T-B-6, bolt pc. mk. T-S-25 to bar provided on bottom of steam drum.
8. Place 2 UB (U-bolts), shown in Drawing No. 532, around downtake nipple and through holes provided in pc. mk. T-S-25 and tighten nuts.
9. Tie packing strip (PS3) with light string to the bar on bottom of steam drum.

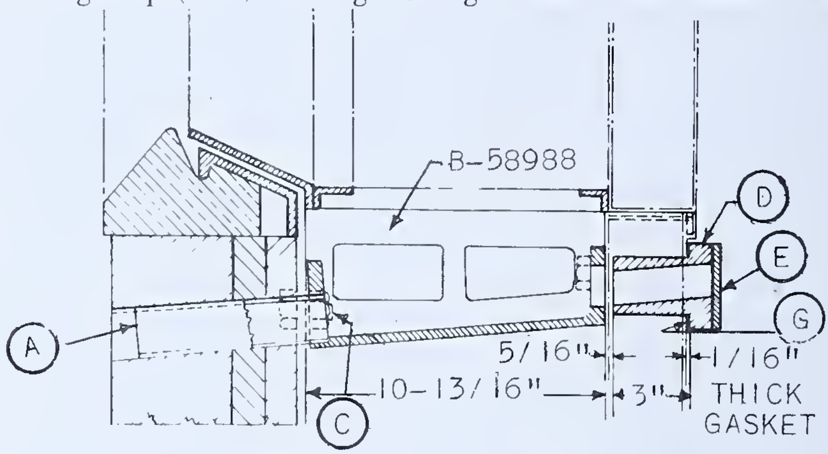


Fig. 533 — *Drains and Riders*

10. With crane, hoist pc. mk. T-F-1 (shown in Drawing No. 532) into place and bolt it fast, using 33—T-B-10 and W 4 (½″ washers).
11. Place pc. mk. T-F-6, right, and bolt fast with 9—4-B-8s as shown in Drawing No. 531 at *A*, using aertite between the two flanges.
12. Place pc. mk. T-F-6, left, and continue as in Step 7.
13. Place pc. mk. F-C-1 (shown in Drawing No. 531) and bolt fast with 2—4-B-8s, using packing strip between both ends.
14. With crane, place pc. mk. F-P-1 (shown in Drawing No. 531), using 62—4-B-8s to bolt fast pc. mk. F-P-1 to pc. mk. T-F-6-R, pc. mk. T-F-6-L, and F-C-1 with packing strip between all flanges.
15. Place pc. mk. T-F-3 (shown in Drawing No. 532, sections *C-C* and *U-U*) and bolt it in place, using 30—4-B-10s, asbestos packing, and W 4s (½″ washers).
16. With crane, place pc. mk. T-F-4 (Drawing No. 532) and bolt it to boiler base with 2—5-B-9s, to pc. mk. T-F-6 and T-F-9 with 3—5-T-B-9s (Tap-bolt), and to pc. mk. T-F-1 with 3—5-T-B-9s and 4-B-9s.

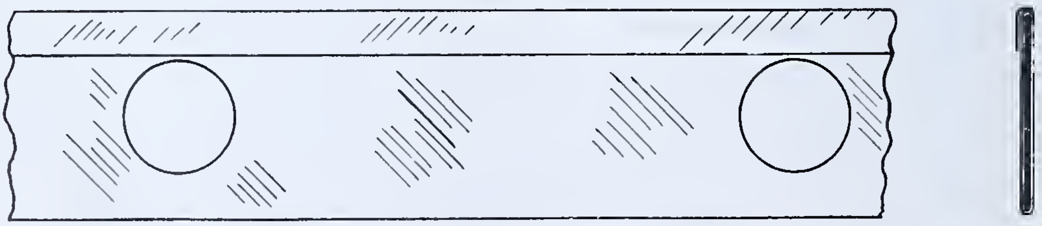


Fig. 534 — *Brass-Bound Asbestos Packing Strip*

17. With crane, place pc. mk. T-F-5 (Drawing No. 532) and continue as in Step 16.
18. Place pc. mk. T-F-2 (Drawing No. 532) and bolt it in position, using 2—5-T-B-9s.
19. Place 4 pc. mk. T-F-7s, as shown in Drawing No. 542, using 8—5-T-B-9s.
20. Locate and place tie bars pc. mk. T-B-12 and pc. mk. T-B-13 (Drawing No. 532 at section *B-B*), and weld to header as shown.
21. Hang 4 doors pc. mk. TD (Drawing No. 532). Section *E-E*.
22. Place pc. mk. F-P-15 (shown in Drawing No. 532) and bolt it in position.
23. Pack rope packing (shown in section *C-C*, Drawing No. 531), place U-B (U-bolt) through F-B-1, and bolt it in position.
24. Place pc. mk. P1 against pc. mk. TF5 and bolt fast, using packing strip and 3-B-7s as shown in Drawing No. 532, loop side.
25. Place pc. mk. P3 on top of pc. mk. P1 and bolt fast, using packing strip and 3-B-7s as shown in Drawing No. 532, loop side.
26. With crane, place pc. mk. P5 against TF5 and under end of steam drum and bolt fast, using packing and 3-B-7s as shown in Drawing No. 532, loop side.
27. Lay out and drill pc. mk. TF8; bolt it fast to bar on steam drum and top of pc. mk. P5, using packing strip, 3-T-B-8s, 3/8" washers, and 3-B-7s as shown in Drawing No. 532, loop side.
28. Continue with box side of boiler as in Steps 24 to 27 (shown in Drawing No. 532, box side).
29. Place pc. mk. P7 against pc. mk. P5 and bolt fast, using packing strip, 3T-B-7, and 3-B-6s as shown at section *E-E* in Drawing No. 532, loop side.
30. Place pc. mk. P6 against pc. mk. P4 and bolt fast, using packing strip, 3-T-B-7, and 3-B-6s as shown at section *E-E* in Drawing No. 532.
31. Pack 3/4" asbestos rope around front water-leg drain as shown in Drawing No. 532, box side.

QUESTIONS

1. **Why is a section of casing never cut with a burning torch until all erection methods have been tried?**
2. **What type of packing strip is used between flanges?**
3. **Why is it necessary for the casing to be airtight?**
4. **Where are the riders and drains located?**
5. **What material is used where the packing strip cannot be used?**
6. **Why is the 1/2" asbestos board used between the downtake nipples and pc. mk. T-S-25?**
7. **What tools are used to bring the holes "fair" in the casing?**

JOB SHEET NO. 33
TO INSTALL AN AIR HEATER

General Information

The hot gases rising from the furnace pass through the superheater generating sections, circulating tubes, and riser tubes on their way to the uptake and stack. From the stack the gases pass into the atmosphere.

When the gases reach the riser tubes, they retain sufficient heat to preheat the air and increase the efficiency of combustion in the furnace. Therefore an air heater has been provided. The air heater (Drawing No. 463) is a number of tubes rolled into tube sheets, designed in a manner to have the outside of the tubes heated with the hot gases from the furnace. The incoming cold air circulates through the inside of the tubes (air heater), and the temperature of the air is raised considerably in its flow to the furnace.

Reference—Drawings 463 and 535 are in the back of the manual. Use them as references for the study of this job sheet.

Tools and Equipment

1. 1—½-lb. ball-peen hammer
2. ⅜″ drift pin
3. Iron wedge
4. ⅜″ spud wrench
5. ⅞″ spud wrench
6. 15/16″ reamer
7. No. 3 drilling machine
8. Six-foot folding rule

Materials

Packing strips ¾″ asbestos rope Aertite

Procedure

1. Place 2 pieces, pc. mk. B-62941 (Air Heater Support Castings), on top of pc. mk. AHC-5 over stud in the top ends of the end uptake headers and bolt in place. See Section *A-A,* Drawing 535.
2. Place pc. mk. AH-7 and pc. mk. AH-8 around riser tubes as shown (Drawing 535—Rear view and section *A-A*), using packing strip, 20—3-B-6s, and 6—3-T-B-8s (tap-bolts).
3. Place AH-6 (Drawing 535, Section *A-A*) and bolt fast, using 51—3-B-T-7s and 33—3-B-6s as shown.

   Use packing strip at all flanges.
4. Weld pc. mk. AH-5 (Drawing 535, side view) into the air heater while it is still on the ground.
5. Install No. 6 soot-blower wall box pc. mk. FM-2729 according to the blueprint, and insert soot-blower element No. 6 in space provided in air heater.
6. Place packing strip and tie with string as shown in Drawing 535 at Section *A-A*.

7. Have riggers hook on to air heater and place it on top of boiler as shown in Drawing 535, side view.
8. Bolt air heater to AH-6 (Drawing 535, at Section *A-A*), using 3-B-7s and packing strip.
9. Bolt air heater to flange provided on back of steam drum as shown in Drawing 535, Section *A-A* at *T*, using 3-B-9s.
10. Fit upper side frame to lower side of air heater, and weld in position as shown in Drawing 535, side view.
11. Place 1″ boards over top of air heater to keep any material from getting down into the tubes.

QUESTIONS

1. **How is an air heater constructed?**
2. **What purpose does an air heater serve?**
3. **What pieces are put on the air heater before it is placed on the boiler?**
4. **What size of bolts are used to bolt AH-6 to the air heater?**
5. **Where are the air-heater support castings located?**
6. **What is the purpose of pcs. mk. AH-7 and AH-8?**
7. **What side of AH-8 is welded to AHC-5?**
8. **Why is planking laid on top of the heater?**

JOB SHEET NO. 34
TO INSTALL A BACK PLATE

General Information

The erection of the boiler has now progressed to the point where the back plate must be installed. The back plate is shown in Fig. 538.

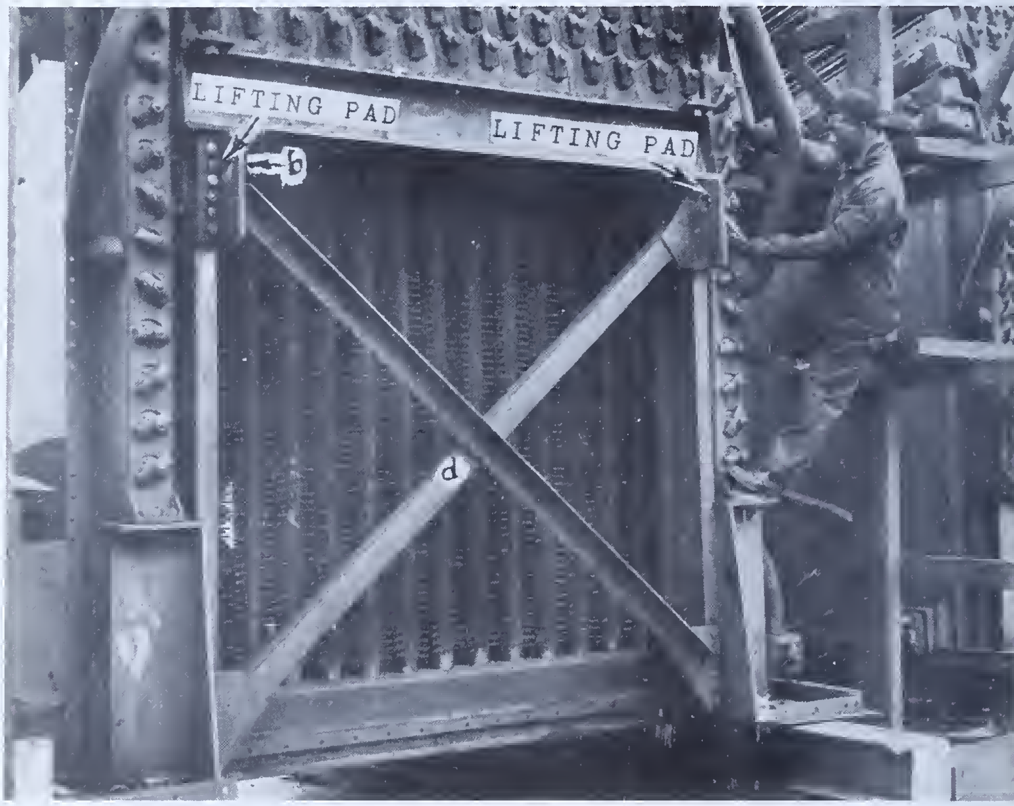


Fig. 536 — *Angle Braces*

The angle braces shown in Fig. 536 at *d* (pc. mk. UA) must be removed to permit the bricklayers to build the rear firebox wall and to allow the boilermakers to get the back plate into position to bolt fast.

When the angle braces are removed, the bricklayer packs chrome ore around the rear water-wall tubes and builds the insulating wall behind the rear water-wall tubes. The insulating wall is composed of magnesium blocks laid in insulating cement. See Fig. 537.

Tools and Equipment

1. 5/8″ spud wrench
2. 5/8″ drift pin
3. Ball-peen hammer

Materials

Aertite
46—5-B-9s
16—5-B-8s
14—5-TB-10s

FIG. 537 — *Rear of Boiler with Rear Firebox Wall Partly Built*

With the insulating wall described above in place and the job cleaned up, proceed as outlined below.

Reference — Drawings 539 and 559 are in the back of this manual. Use them as a reference for the study of this job sheet.

FIG. 538 — *Back Plate Installed*

PROCEDURE

1. Remove angle braces (pc. mk. UA) *d* shown in Fig. 536.
2. Pick up pc. mk. UP1, right hand (Drawing 539), and move it into position as shown.
3. Bolt the back plate (Drawing 539) fast to I-beam (pc. mk. U1), to U-channel (pc. mk. UC), and to brick pan (pc. mk. BP3).

4. Pick up pc. mk. UP1, left-hand, and move it into position as shown.
5. Bolt the back plate fast as in Step 3; bolt it also to the right-hand back plate.
6. Install two door sleeves (pc. mk. ID and IE) and two cover plates (pc. mk. 2) as shown in Drawing 559 and Fig. 538.
7. Replace angle braces which were removed in Step 1.

   Detail *AB* in Drawing 539 shows the upper end of the angle braces (pc. mk. UA). There are six 13/16″ holes in the plates which are welded to the angle-brace ends.
8. Obtain two pieces of angle 3″ x 6″ x 1″, 13¾″ long. See Fig. 536 at *b*.
9. Drill 13/16″ holes in one leg of each angle to fit the plates described in the note above.
10. Burn a hole 2½″ in diameter in the other leg of each angle according to the leader's instructions. See Fig. 536 at *b*.
11. With ¾″ bolts, 3¼″ long, bolt the angles (one on each side) to the plates on the ends of the angle braces. See *e* and *f*, Drawing 539 and Fig. 536.

    Use only the two end bolt holes in each angle.
12. Ream the rest of the holes through angle (pc. mk. UC) and plate to 15/16″.
13. Install ⅞″ x 3¼″ bolts in these eight reamed holes.
14. Remove the end ¾″ bolts and ream the holes to 15/16″ diameter. Install ⅞″ bolts in place of the ¾″ bolts.

    These angles are bolted in place to be used for lifting the boiler when complete. They are called lifting pads. See Fig. 536.

QUESTIONS

1. **Why are the angle braces (pc. mk. UA) removed?**
2. **What size bolts are used to bolt pc. mk. UP-1 in position?**
3. **What material is used between all the flanges of this job?**
4. **What size of angle is used for lifting pads?**
5. **To what diameter are the holes in the lifting pads finally reamed out?**

JOB SHEET NO. 35
TO ERECT REAR AIR CASING

General Information

The rear air casing forms an airtight passage from the bottom rear of the air heater to the bottom rear of the boiler foundation. The rear air casing serves the same purpose as the front air casing in that it permits access to the uptake sections for inspecting, cleaning, and repairing and keeps the hot air in the boiler from escaping to the boiler room. It is important to have air casings erected in strict accordance with the drawings and all adjoining pieces of casing and joints absolutely airtight. Where joints will not admit a packing strip, they should be made tight with Fenox (sealing compound).

No casing should be cut with a burning torch until all methods of erection have been tried. Burning one piece of casing to make it fit right may throw the remaining parts of the casing out of alignment. Most of the casing can be erected with little or no trouble. Use a drift pin and a ball-peen hammer to bring the holes in adjoining pieces into correct alignment. No allowance in measurements is made for the packing strip. An iron wedge inserted between two adjoining flanges will be sufficient to permit entrance of the packing strip. Holes that cannot be aligned by drifting must be reamed.

Reference. Drawings 541 and 542 are in the back of this manual. Use them as a reference for the study of this job sheet.

Tools and Equipment

1. 1½-lb. ball-peen hammer
2. ⅜″ drift pins
3. ½″ drift pins
4. Iron wedge
5. ⅜″ spud wrench
6. ⅞″ reamer
7. ½″ spud wrench
8. 9/16″ reamer
9. No. 1 drilling machine
10. Six-foot folding rule

Materials

Brass-bound asbestos packing strips

Sealing compound (Fenox)

Procedure

1. Place pc. mk. 65 at base of boiler and bolt fast, using 5-B-9s, as shown at section *Q-Q* in Drawing 541.
2. With the crane, place pc. mk. AC19LH along the side of rear water leg and bolt fast using aertite and 4-B-10s as shown at sections *W-W* and *AB-AB* in Drawing 541.
3. With crane, place pc. mk. 68RH on opposite side of boiler and continue as in Step 2 as shown at sections *BB-BB* and *AB-AB* in Drawing 541.
4. With the crane, place pc. mk. AD1, right, on the boiler base at the rear as shown in Fig. 543.

5. Bolt fast to the boiler base and to pc. mk. 65 shown at section *Q-Q*, Drawing 541.
6. With the crane, place pc. mk. AD1, left, on the boiler base at the rear as shown in Fig. 543 and Drawing 541.
7. Bolt fast as in Step 2.

FIG. 543 — *Rear Air Casing Installed*

8. With the crane, install pc. mk. AC5 on top of pc. mk. 65 and between pc. mk. AD1, right, and pc. mk. AD1, left, as shown in section *U-U* and *R-R*, Drawing 541.
9. Bolt pc. mk. AC5 to pc. mk. AD1, right, and pc. mk. AD1, left.
   Use packing strip and 3-B-7s.
10. With the crane, place pc. mk. AC18, shown at section *T-T*, in Drawing 541.
11. Bolt fast pc. mk. AC18, using packing strip, 3-B-9s, and 5-B-10s.
12. With the crane, place pc. mk. AC4 as shown in Drawing 541 at section *AC-AC* and *N-N*.
13. Bolt fast pc. mk. AC4 to pc. mk. AC18 and pc. mk. AD1, using packing strip and 3-B-8s.
14. Place pc. mk. AC9 (on top of pc. mk. AC4 and pc. mk. AD1) and bolt fast as shown at section *AD-AD* in Drawing 541, using packing strip and 3-B-7s.
15. Place pc. mk. AC16 L.H. against pc. mk. AC8 and bolt fast using packing strip and 3-B-7s as shown at section *C-C* in Drawing 541.
16. With the crane, place pc. mk. AC8 (on top of pc. mk. AC9) and bolt fast, using packing strip and 3-TB-7s as shown at section *AD-AD* in Drawing 541.
17. With the crane, place pc. mk. AC2 (on top of pc. mk. AC4 and against pc. mk. AC8) and bolt fast as shown in section *X-X* and *M-M*, using packing strip, 3-B-6s, and 3-B-7s.
18. Place pc. mk. AC21 against pc. mk. AC2, pc. mk. AC2, and pc. mk. AC2.
    Hold in place with a drift pin until the opposite side pc. mk. AC3 and pc. mk. AC2 are in place.

19. With the crane, place pc. mk. AC3 (on top of pc. mk. AC18 and against pc. mk. AD1) and bolt fast, using packing strip and 3-B-8s as shown at section *AC-AC* and *N-N* in Drawing 541.
20. Place pc. mk. AC9, right hand (on top of pc. mk. AC3), and bolt fast, using packing strip and 3-B-7s as shown at section *AD-AD* in Drawing 541.
21. With the crane, place pc. mk. AD2, right hand (on top of pc. mk. AC9 and pc. mk. AC3), and bolt fast, using packing strip and 3-TB-7s as shown at section *AD-AD* in Drawing 541.
22. With the crane, place pc. mk. AC2 (on top of pc. mk. AC3 and between pc. mk. AC21 and pc. mk. AD2) and bolt fast, using 3/8" bolts and a packing strip as shown in Drawing 541.
23. With the crane, place pc. mk. AC7, right hand (on top of pc. mk. AD2), and bolt fast, using packing strip and 3-B-7s as shown at section *AF-AF* in Drawing 541.
24. With the crane, place pc. mk. AC7, left hand (on top of pc. mk. AC8), and bolt fast, using strip and 3-B-6s as shown at section *K-K* in Drawing 541.
25. Place pc. mk. AC20 (on top of pc. mks. AC2 right hand and AC2 left hand). Hold in place with a drift pin until pc. mk. AC1 is in place.
26. Remove drift pins mentioned in Steps 14 and 21.
27. With the crane, place pc. mk. AC1 (on top of pc. mk. AC20 and between pc. mk. AC16, left hand, and pc. mk. AC17, right hand) and bolt fast, using packing strip, 3-B-8s, and 3-B-7s as shown at sections *C-C* and *D-D* in Drawing 541.
28. With the crane, place pc. mk. AC12 (on top of pc. mk. AC1) and bolt fast, using packing strip and 4-B-9s as shown at section *A-A* in Drawing 541.
29. With crane, place pc. mk. AC11 between AC14 and AC19 and bolt fast, using packing strip and 3-B-7s as shown at sections *P-P* and *C-C* in Drawing 541.
30. With crane, place pc. mk. AC10 on top of pc. mk. AC11 and between pc. mk. AC14 and pc. mk. AC19 and bolt fast, using packing strip and 3-B-7s as shown at sections *AD-AD* and *C-C* in Drawing 541.
31. With crane, place pc. mk. AC11, right hand, between pc. mk. 68RH and AC, left hand, and bolt fast, using packing strip and 3-B-7s as shown in sections *C-C* and *P-P* in Drawing 541.
32. With crane, place pc. mk. AC10, right hand, and continue as in Step 27.
33. Place pc. mk. AC6 between AC7 and airheater and bolt fast, using packing strip, 3-B-7s, and 3-B-6s as shown at sections *E-E* and *K-K* in Drawing 541.
34. Place pc. mk. AC6 opposite side of boiler, and continue as in Step 31.
35. Place pc. mk. AC13 on top of pc. mks. AC7 and AC6 and bolt fast, using packing strip and 3-B-7s as shown at section *B-B* in Drawing 541.
36. Place pc. mk. 13 on opposite side of boiler, and continue as in Step 33.
37. Assemble pc. mk. 76 and pc. mk. 74, using 4-B-9s, bolt assembly to pc. mk. 71 with 4-B-9s and weld pc. mk. 74 to uptake header.

38. Assemble pc. mk. 77 and pc. mk. 71, using 4-B-9s, and bolt assembly fast to AC20; then weld pc. mk. *C* in Drawing 541.
39. Assemble pc. mk. 75 and pc. mk. 74, using 4-B-9s, and bolt assembly fast to pc. mk. 71; then weld to uptake header as shown in Drawing 541.
40. Place 3 pieces of grating (pc. mk. G1), and bolt in position, using ¼″ hook bolts as shown in Drawing 541.

QUESTIONS

1. **In what respect is the rear air casing similar to the front casing?**
2. **Which pc. mk. no. is erected first?**
3. **What size of bolts are used in section *U-U*?**
4. **At which section is pc. mk. AC-21 shown?**

JOB SHEET NO. 36
TO ERECT UPPER SIDE CASING

General Information

The upper side casing differs from the rest of the boiler casing in that it is not air-cooled. It is merely an angle frame lifted to the generating section of the boiler. Insulation is placed between the generating tubes and the 10-gauge sheets that make up the exterior of the boiler sides. After these sides are in position, the outer edges are seal-welded. Also at this point of erection the soot-blower wall boxes number 3, 4, and 5 are installed. These boxes must be installed in strict accordance with the blueprints. Drawings No. 544 and No. 545 show the sheets in position. These sheets must be removed so that the bricklayers can lay the insulation.

Reference—Drawings numbered 544, 545, 546, and 547 are in the back of the book. Use them as a reference for the study of this job sheet.

Tools and Equipment

1. 1½-lb. ball-peen hammer
2. ⅜″ drift pins
3. ½″ drift pins
4. Iron wedge
5. ⅜″ spud wrench
6. ⅜″ socket wrench
7. 7/16″ reamer
8. No. 1 drilling machine
9. ⅝″ spud wrench

Materials

Packing strips | Fenox

Procedure

1. Remove sheets, pc. mks. SP37, SP35, SP36, and SP36 (loop side of boiler), shown in Drawing 544.
2. Have bricklayers lay upper side tile and insulation.
3. Locate from drawing and burn out hole in pc. mk. SP37 for soot-blower wall box No. 5; drill holes and bolt soot-blower wall box to pc. mk. 37 according to the drawing.
4. Locate from drawing and burn out hole in pc. mk. SP36 for soot-blower wall box No. 4; continue as in Step 3.
5. Locate from drawing and burn out hole in pc. mk. 36 for soot-blower wall box No. 3; continue as in Step 3.
6. When bricklayers have laid insulation, replace pc. mks. SP35, SP36 forward, SP36 aft, and SP37, using ⅝″ nuts, ⅜″ x 1″ tap bolts, packing strip, and ⅜″ washers as shown in Drawing 544.
7. Weld outer edges of sheets, pc. mks. SP36 forward, SP36 aft, and SP37, shown by symbol ⅛V in Drawing 544.
8. Install soot-blower elements S3, S4, and S5 through soot-blower wall boxes No. 3, No. 4, and No. 5, pc. mk. FM 7164.

9. Remove pc. mks. SP10, SP11, and SP12 shown in Drawing 545, box side.
10. Have bricklayers lay insulation.
11. When bricklayers are finished, replace pc. mks. SP10, SP11, and SP12 and bolt in position using 3/8" x 1" tap bolts, packing strip, 3/8" washers, and 5/8" nuts as shown in Drawing 545.
12. Weld edges of all sheets, pc. mks. SP10, SP11, and SP12, as shown in Drawing 545 by the symbol 1/8V.
13. With crane, place pc. mk. AC6 and bolt fast, using packing strip, 4-B-8s, and 5/8" nuts as shown at sections *AA-AA* and *CC-CC* in Drawing 546.
14. With crane, place pc. mk. ACF1 and bolt fast, using packing strip, 4-TB-8s and 3-TB-8s as shown at sections *D-D* and *I-I* in Drawing 547.
15. Place pc. mk. ACP4 and bolt fast, using packing strip, 4-B-8s, and 3-B-7s as shown at sections *G-G*, *F-F*, and *I-I* in Drawing 547.

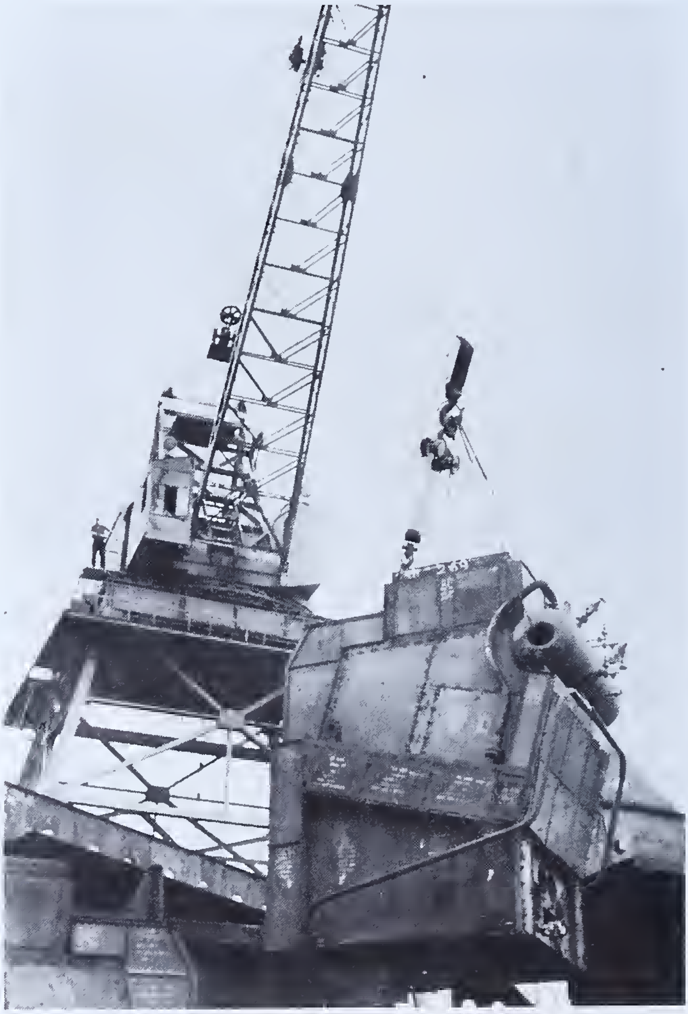


FIG. 548 — *Landing a Boiler Aboard Ship*

Taking the Boiler Aboard Ship

After the work of erecting the boiler has been completed to the point where the upper side casing has been installed, the whole assembly (Fig. 548) is placed aboard the ship. The boiler is picked up by the crane and landed aboard the ship. The foundation upon which the boiler is bolted down aboard ship should be ready to receive it. The next job sheet describes the laying out and drilling of the foundation.

QUESTIONS

1. **What is the difference between the upper side casing and the rear air casing?**
2. **What material is used to insulate the upper side casing?**
3. **What is meant by box side and loop side of the boiler?**
4. **Are the soot-blower wall boxes installed on the box side or loop side of the boilers?**
5. **On what sheet is No. 5 soot-blower wall box installed?**
6. **On Drawing 547, locate and explain the procedure for installing pc. mk. ACP-4.**

JOB SHEET NO. 37
TO LAY OUT AND DRILL A BOILER FOUNDATION

General Information

A boiler foundation is the main support for the steam boiler aboard ship. The foundation is built on the boiler-room flat, which is situated aft of the engine room. See Fig. 549. Laying out a foundation means to locate the center lines of the boiler and the centers of the bolt holes. The position of these lines is given on the blueprint. See Drawing 550.

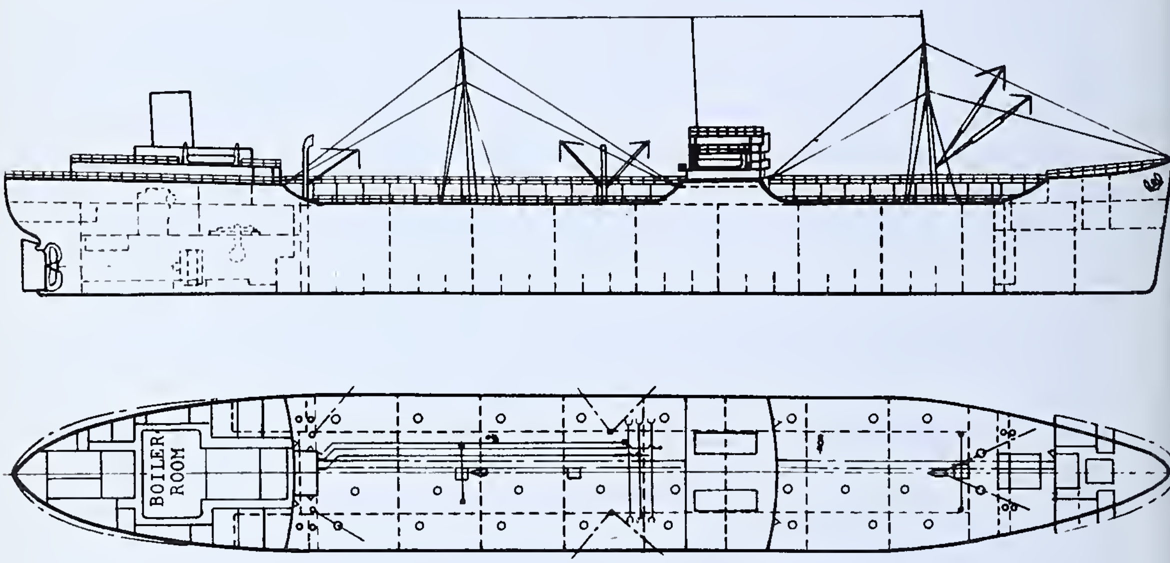


Fig. 549 — *Location of Boiler Room*

The centers of the bolt holes shown in Drawing 550 are laid off from a template. The template has center lines which are plainly marked. After the center lines are located on the foundation, the template is laid on the foundation so that the center lines on both foundation and template match. The centers of the bolt holes are then center punched through the template. (The template is made of template paper.)

Tools and Equipment

1. Wooden straightedge 12′ long
2. Plumb bob
3. Chalk line
4. 1½-lb. ball-peen hammer
5. Center punch
6. 50′ steel tape
7. Six-foot folding rule
8. Four 6″ C clamps
9. ½″ and 1—¼″ twist drills
10. No. 4 air drilling machine
11. Drill stick

Materials

Soapstone pencil
Chalk
Marking paint

Safety Precautions

1. Wear safety hat and safety shoes.
2. Watch the movements of other workmen to avoid injuries caused by falling, swinging, or projecting materials.
3. Never lay drilling machine down, with the drill in the drill chuck.
4. Never hook up a drilling machine and then raise or lower it by means of the air hose. The coupling could "let go," or the air hose might break; either could have serious results.

Note—There are two foundations; one is located to port and the other is located to starboard. The procedure given below is followed in the layout for the port foundation. As each step is completed the movements should be repeated on the starboard layout. The layout work will thus be completed to port and starboard about the same time.

Reference—Drawing 550 is in the back of the book. Use it as a reference for the study of this job sheet.

Procedure

1. Check the length of the boiler foundation structure with the blueprint. See Drawing 550 in back of book.

   The length should be the same.
2. Measure, from the forward end of the foundation structure aft, port and starboard, one inch, and mark with a soapstone pencil. See Drawing 550 at *x-y*.
3. Stretch a chalk line through these points and snap it. See Drawing 550 at *r*.
4. Place the straightedge flat across the forward inboard ends of the foundations even with the chalk line and hold it in position with C clamps.
5. Drop a plumb line over the forward edge of the straightedge with the plumb bob in line with the ship center line as at *p*, and tie it fast.
6. Measure from the plumb line, port, to the center of the foundation, and mark with soapstone as shown in Drawing 550 at *t*.
7. Remove the straightedge and plumb line.
8. Measure from foundation center line (*t*) to the center of the corner box on the foundation, Drawing 550 at *w-w*, and mark with soapstone pencil.
9. Measure, from the after end of the foundation structure, FWD, port and starboard, one inch, and mark with a soapstone pencil. See Drawing 550 at *e* and *f*.
10. Proceed on the after end as was done (Step 3 through Step 7) on the forward end.
11. Measure from foundation center line (*t*) to the center of the corner box on the foundation, Drawing 550 at *g-g*, as in Step 8. Place and clamp the template, already prepared by boiler shop layout man, to the foundation on the center lines to match the markings on the template; center punch the locations of the bolt holes.

    There are usually 32 holes in each foundation.

9. Place pc. mk. ACP1 between boiler base and pc. mk. ACF2 at rear side of boiler and bolt fast, using packing strip, 3-TB-7s, 3-B-8s, and 3-B-6s as shown at sections *H-H*, *J-J* and *S-S* in Drawing 547.
10. Place pc. mk. ACP3 between boiler base, pc. mk. ACF2, and pc. mk. ACP2 and bolt fast, using packing strip, 3-TB-7s, 3-B-6s, and 3-B-7s shown at sections *J-J*, *B-B*, *E-E* and *A-A* in Drawing 547.
11. Continue on loop side of boiler (Steps 6 to 10) as shown in Drawing 546.

QUESTIONS

1. **From Drawing 552 explain the installation of pc. mk. LSF7.**
3. **How many tie bars (pc. mks. ACB3) are used in the erection of a boiler?**
4. **Are washers used in bolting parts (pc. mks. RP1, RP2, and RP2) to the lower superheater header?**
5. **Why are packing strips used between the flanges of parts (pc. mks.) ACP1, ACP2, and ACP3?**

JOB SHEET NO. 39
TO INSTALL A SOOT BLOWER

General Information

The boilers are equipped with GB9 valves in the head soot blower so that the accumulations of soot caused by the combustion of the fuel in the furnace can be removed. The GB9 valve is manufactured by the Diamond Power Specialty Company. Steam at a high velocity blows the soot from the outside of the tubes in the boiler through these soot blowers.

The soot-blower head (Fig. 553 and Fig. 556) is connected to an element which may be of plain steel, alloy steel, or "calorized" (impregnated with aluminum) steel. The difference in the metals corresponds to the boiler temperature at which they are to be used. These elements are closed at one end, have venturi nozzles spaced on the element corresponding to the spacing of the boiler tubes, and are supported by bearings which are clamped to the boiler tubes.

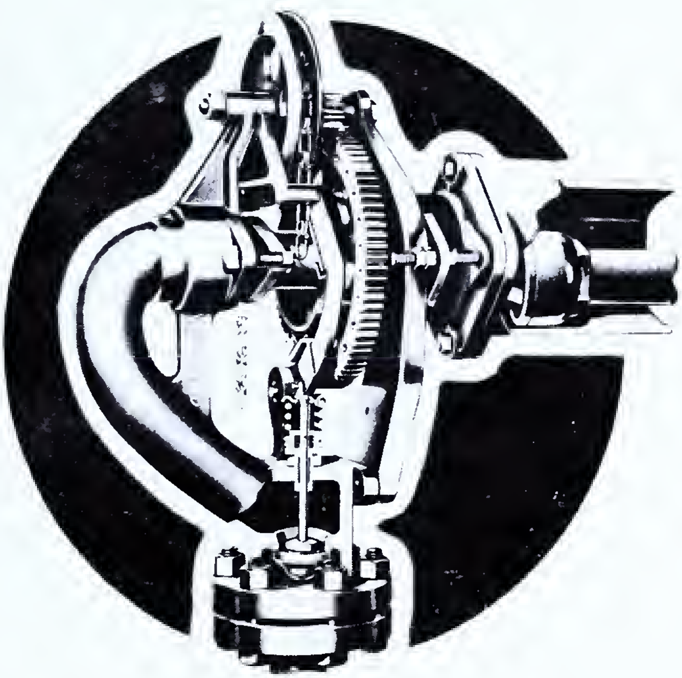


*Fig. 553 — *Soot-Blower Head*

The soot blower is chain-operated, and the soot blowing is done while the boilers are in operation. Soot is blown from boiler tubes at regular intervals. The arc of soot blowing may be 360° or it may be set to any number of degrees which are given on the drawings. Figure 554 shows a soot blower, stuffing box, and element in operation. Turning the chain operates a cam by means of a geared pinion; the cam operates a cam trigger which in turn opens the valve. The valve remains in a closed position when the soot blower is not in operation.

When the valve is open, it remains open until the arc of soot blowing is completed; the speed of the arc is controlled by the speed at which the chain is operated.

Reference—Drawings 555, 556, and 557 are in the back of the manual. Use them as a reference for the study of this job sheet.

* Courtesy of the Diamond Power Specialty Co.

JOB SHEET NO. 40

TO INSTALL THE INTERNAL BAFFLES AND SWASH PLATES

General Information

The baffles, swash plates, dry pipe, surface blow, and desuperheater are located i the steam drum. The baffles and swash plates are located according to Drawing 558 The purpose of the baffles is to keep the water returning to the steam drum throug the circulating tubes from mixing with the saturated steam in its flow to the dry pip and thence to the superheater.

The dry pipe is a further aid in eliminating the water held in suspension by th steam. The surface blow is used to remove any foreign matter resting on the top o the water in the steam drum. The purpose of the swash plates is to keep the water i the steam drum from swashing around with the roll of the ship. The lower halve of the swash plates are bolted into position before the pipefitters install the desuper heater.

The purpose of the desuperheater is to remove part of the heat in the superheate steam to run units smaller than the main turbine; for example, the boiler feed pump During the procedure of installing the numerous parts in the steam drum, car should be exercised to make sure that no nuts, bolts, or tools lodge in the tube Carelessness in this regard will have serious consequences in the future operation o the boiler.

Reference—Drawing 558 is in the back of this manual. Use it as a reference fo the study of this job sheet.

Tools and Equipment	Materials
1. 5/8″ spud wrench	None
2. 6′ folding rule	

Procedure

1. On swash plate pc. mk. 1, weld pcs. mk. 11 (2) and 12, as shown on Drawin 558 at *c* and *a*.
2. Proceed with opposite swash plate, pc. mk. 1, in like manner.
3. Place the two above-mentioned pieces in the steam drum and bolt them fas using four 5-B-10s as shown in Drawing 558 at *a* and *b*.

   When these are complete, pipefitters install desuperheater chemical feed lin and surface. Proceed with Step 4.
4. On swash plate pc. mk. 2, weld pcs. mk. 13 (2) and 8 as shown on Drawin 558 at *d* and *a*.
5. Proceed with opposite swash plate, pc. mk. 2, in like manner.
6. Place the two above-mentioned pcs. in the steam drum and bolt fast, using 1 5-B-8s and 2 5-B-10s as shown in Drawing 558 at *a* and *b*.

7. Place 2 pc. mk. 10 and bolt fast, using 2 5-B-12s and 2 5-B-9s as shown in Drawing 558 at *b*.

   The installation of the swash plates is now completed. Proceed with the baffle plates as in Step 8.

8. Place 2 baffle support bars pc. mk. 9 and bolt fast, using 2 5-B-12s at the bottom end only as shown in Drawing 558 at *a* and *b*.
9. Place baffle plates pcs. mk. 3 (2) and 17 and bolt loosely as shown in Drawing 558 at *a* and *b*.
10. Place lower baffle plates, pcs. mk. 4 (2) and 16, and bolt loosely as shown in Drawing 558 at *a* and *b*.
11. Place 2 butt straps, pcs. mk. 15, and bolt loosely as shown in Drawing 558 at *a*.
12. Proceed to tighten all bolts.

    The bolts are placed loosely in Steps 10, 11, and 12 so that the adjoining pieces may be installed with a minimum of effort insomuch that there is more play between two adjoining pieces when bolted loosely than when bolted up tight. When the nuts are drawn up tightly, the bolt end must come flush with the nut surface. Shorter or longer bolts must be substituted if necessary.

QUESTIONS

1. **What is the purpose of the baffle plates?**
2. **What is a dry pipe?**
3. **What service does a surface blow render?**
4. **What is the purpose of a desuperheater?**
5. **Why is it necessary to install the lower half of the swash plates before the pipefitters install the desuperheater?**

PART IX

MISCELLANEOUS INSTALLATIONS

JOB SHEET NO. 42
TO ERECT UPTAKES

General Information

An uptake is a development of bent plates and stiffeners used to carry the hot gases from the boiler to the stack. It is laid out, burned, and bent in the boiler shop, and the various plates are erected by the boilermakers outside. The uptake (Fig. 561) is of all-welded construction. It is insulated on the outside with magnesium blocks and finished off smoothly. The uptakes are erected in pairs and are supported by rods attached to the underside of the fidley deck in such a manner as to eliminate any undue strain upon the boilers caused by expansion and contraction at the boiler top. Fig. 561 shows an uptake.

Reference — Drawings 241-880-1 and 241-880-2 are in the back of the book. Use them as a reference for the study of this job sheet.

Fig. 561 — *Port Uptake and Jig*

2. Place and fix expansion plates on the inside of the angle frame, and tack weld them to the opposite toe of the angle as shown in Fig. 566, and Drawing 241-880-2, Detail *B*.
3. Continue with port uptake box as in Steps 1 and 2.
4. Tack weld 16 pieces of 2″ x 2″ x ¼″ angle, 2″ long, to expansion plates as shown in Fig. 566.

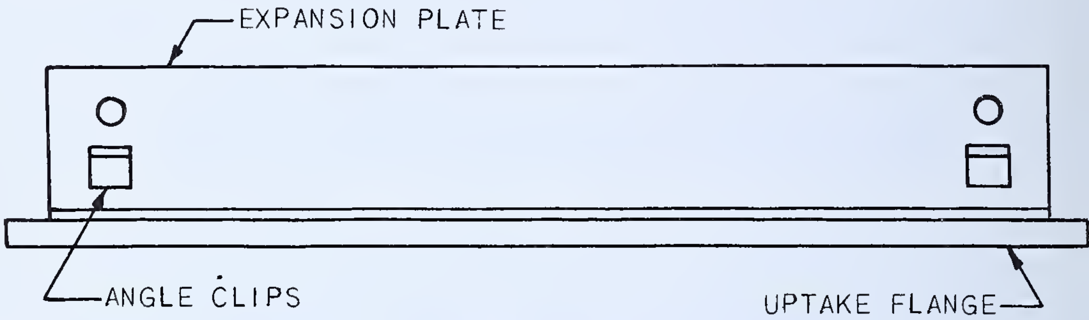


Fig. 566 — *Uptake Flange and Expansion Plate*

5. With the crane, hang the starboard inboard plate of uptake, pc. mk. 2, upon angles mentioned in Step 4 and bolt fast with 1″ x 2″ bolts to expansion plate as shown in Drawing 241-880-1. Brace to keep in an erect position, and unhook crane.

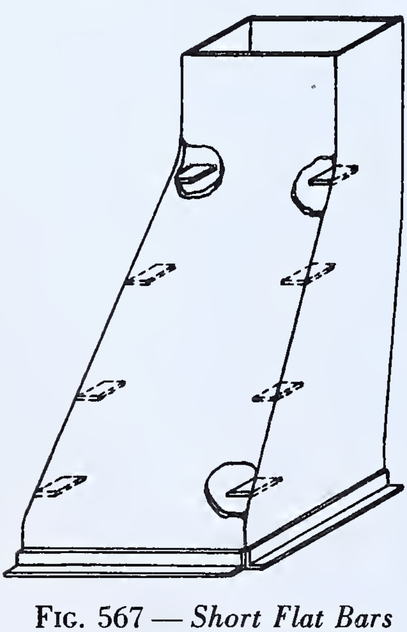


Fig. 567 — *Short Flat Bars Welded to Plates*

Fig. 568 — *Swinging the Outboard Starboard Plate into Position*

6. With the crane, hang the AFT starboard plate, pc. mk. 1, and bolt fast, using 1″ x 2″ bolts and nuts, to expansion plate, as shown in Drawing 241-880-1.
7. With the plate still hanging on the crane, fit the AFT starboard plate to starboard inboard plate, as shown in Drawing 241-880-2 at detail K.
8. With the crane, hang the FWD starboard plate, pc. mk. 1, and bolt fast to expansion plate, as shown in Drawing 241-880-1.
9. With the crane, hang the FWD starboard plate, pc. mk. 1, and bolt fast to expansion plate, as shown in Drawing 241-880-1.
9. With the plate still hanging on the crane, fit FWD starboard plate to inboard starboard plate as explained in Step 7.
10. Weld 8 pcs. of 3″ x ¼″ flat bar to the inside of FWD and AFT starboard plates as shown in Fig. 567 in preparation for hanging outboard starboard plate.
11. With the crane (Fig. 568), hang the outboard starboard plate, pc. mk. 1, and bolt fast to expansion plate.

    Lower the crane hook so that outboard starboard plate rests against flat-bar strips mentioned in Step 10, and unhook crane.
12. Fit outboard plate to fore-and-aft plates as shown in Drawing 241-880-1 and Drawing 241-880-2, detail *K*.
13. Proceed to erect port uptake in the manner explained in Steps 5 to 12.
14. Fit 2″ x 2″ x ¼″ angle, pc. mk. 5, on inside corners of both uptakes as shown in Drawing 241-880-2, detail *K* and detail *H*.

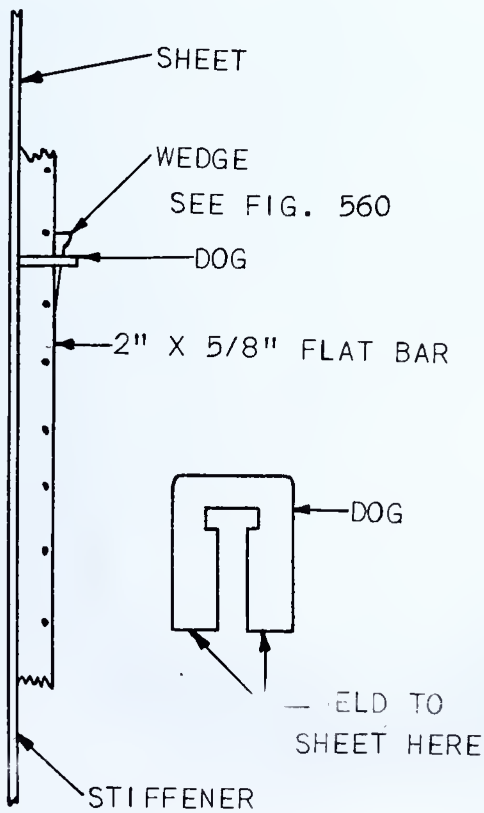


FIG. 569 — *Welding Flat Bar to Uptake*

15. Drill $\frac{1}{4}''$ holes in $2''$ x $\frac{5}{8}''$ flat bar, pc. mk. 6. Space holes at $16''$ centers anc $\frac{3}{8}''$ in from one side only.
16. Fit $2''$ x $\frac{5}{8}''$ flat bar on edge to outside of both uptakes on set marks provided with the holes mentioned in Step 15 on the outside. (Fig. 569 shows typica method of fitting flat bar to uptake sheets.)
17. Fit $2''$ x $2\frac{1}{4}''$ angle, pc. mk. 5, to bottom of uptakes on all eight sides as shown ir Drawing 241-880-1 and -2, detail *B*. (Fig. 570 shows method of fitting angle tc sheet.)
18. Fit reinforcing plate, pc. mk. 87, for access door to forward sheets as shown ir Drawing 241-880-1 and Drawing 241-880-2 at detail *C*. (Fig. 573 shows methoc of fitting and welding the reinforcing plate.)
19. Fit angle frame to inside of access hole as shown in Drawing 241-880-2, detail *C*

FIG. 570 — *Fitting Angle to Sheet*

FIG. 571 — *Completed Uptake, Three-Quarter View*

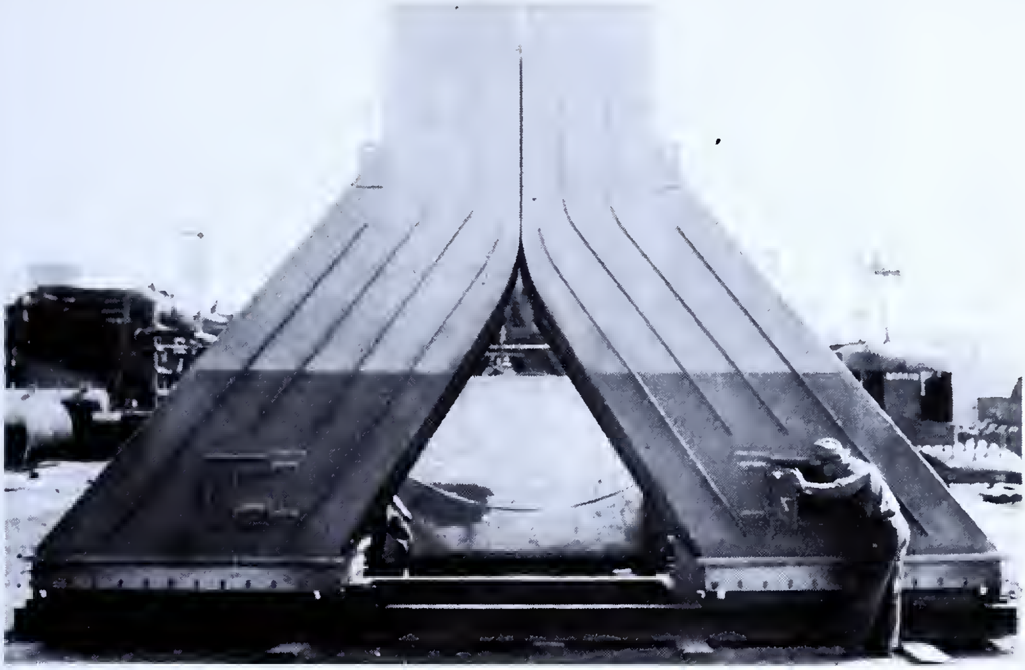


Fig. 572 — *Completed Uptake, Forward Side*

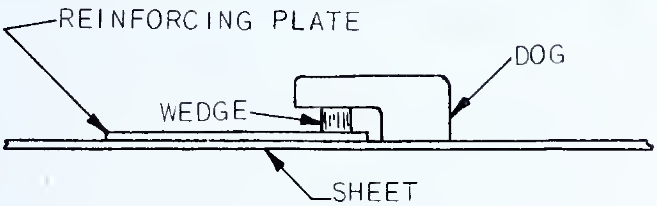


Fig. 573 — *Welding Reinforcing Plate*

20. Fit access doors to uptake as shown in Drawing 241-880-2, detail *C*, and make sure that center line of hinge pin is on the edge of the reinforcing plate.
21. Fit to uptake on outboard side the support brackets, pc. mk. 76, and reinforcing plates as shown in Drawing 241-880-1, detail *M*.
22. The uptakes are then welded according to specifications and are ready to put aboard ship.

QUESTIONS

1. **What is the purpose of an uptake?**
2. **Why is the use of an expansion joint on an uptake necessary?**
3. **What size of angle is used for the flange at the boiler top?**
4. **Explain method of fitting 2″x⅝″ flat-bar stiffeners to outside of uptake.**
5. **What is the purpose of the holes in the stiffener (shown in Fig. 569)?**
6. **When the access doors are being fitted what caution must be used regarding the hinges?**
7. **What is meant by the term "Well-Fitting"?**

JOB SHEET NO. 43
TO ERECT A SMOKESTACK

General Information

The smokestack is a development of rolled plates, curved angles and stiffeners consisting of an outer stack, an inner stack, and a canopy. The plates are laid out, burned to the layout lines, and rolled to shape in the boiler shop. The angles are shaped in the blacksmith shop. The smokestack is the last section of conduit through which the hot gases arising from the burning fuel in the boiler furnace pass before escaping into the atmosphere.

The inner stack (the true stack) is designed in size and shape to accommodate the gases from the boiler. The outer stack or casing is elliptical in shape. It is welded to the fidley or casing top and is further supported by guy lines. The outer stack is not fastened securely at any point to the inner stack and canopy. This arrangement permits the inner stack to expand and contract without distorting the outer stack. The plates of both the outer and inner stacks are called courses. There are four of these courses in each stack.

Reference—Drawings 241-880-3 and 241-880-4 are in the back of this book. Use them as a reference for the study of this job sheet.

Tools and Equipment

1. 1½-lb. ball-peen hammer
2. 8-lb. maul
3. Pneumatic chipping hammer
4. Gouge chisels
5. Side-cutting chisels
6. Center punch
7. Chalk line
8. No. 2 drilling machine
9. 9/16″ drill
10. 12′ wooden straightedge
11. Fifty-foot steel tape
12. Six-foot folding rule
13. Twelve-inch steel square
14. Twenty-four inch level

Materials

Soapstone

Chalk

Procedure for Erecting Outer Stack

1. Assemble stack angles on jig as shown in Fig. 574, making sure that the heel of angle is set to set marks before welding butt joints.
2. Place an angle pc. mk. 17 on a level temporary base plate and tack weld to only as shown in Fig. 575.

   The angle mentioned in Step 2 is only temporary and does not form a part of the completed stack.
3. With crane, place No. 1 course port and starboard on base plate around outside of angle.
4. Unhook crane and move both plates into position with pinch bars.
5. Fit forward vertical seam by methods shown in Figs. 578 and 578 and Drawing 241-880-4 at section *F-F*.

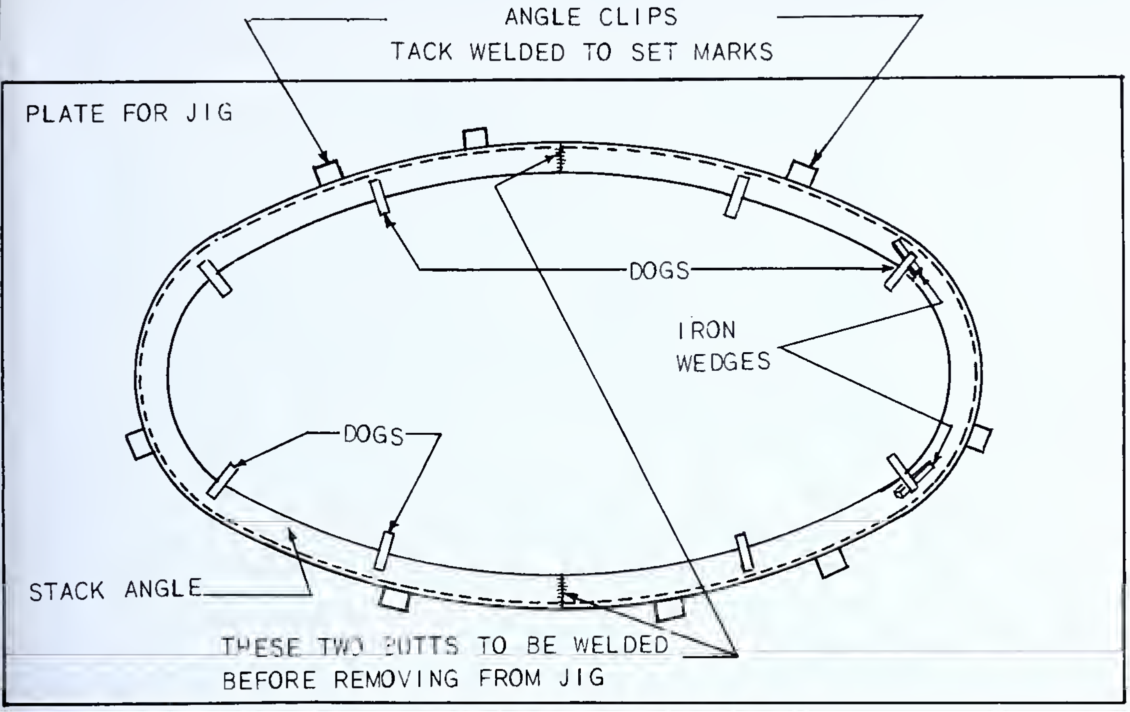


FIG. 574 — *Stack Angle on Jig*

6. On inside of No. 1 course, tack weld six pieces of ¼″ x 3″ x 6″ flat bar evenly spaced to support angle pc. mk. 17.
7. With crane, place angle pc. mk. 17 on inside of No. 1 course as shown in Drawing 241-880-3; unhook crane.

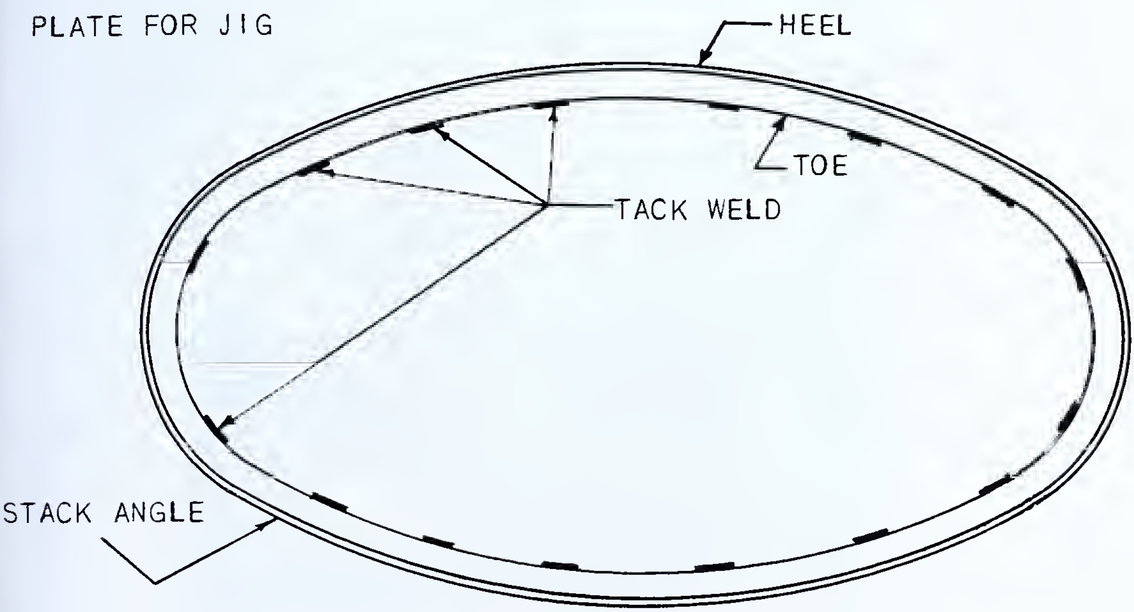


FIG. 575 — *Toe of Angle Tack Welded to Plate*

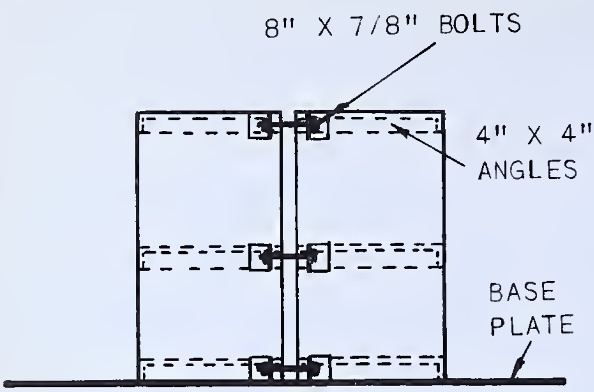


FIG. 576 — *Fitting Vertical Seam*

8. Tack weld on inside top of No. 1 course six pieces of ¼″ x 3″ x 6″ flat bar in preparation for placing angle pc. mk. 18 as shown in Drawing 241-880-3.
9. With crane, place angle pc. mk. 18 on top of pieces of flat bar mentioned in Step 8; unhook crane.
10. Fit after vertical seam as shown in Figs. 576, 578 and 579.

NOTE—The object of this procedure is to pull the plates of No. 1 course tight around the three angles. This will almost eliminate any fitting of the angles on the inside of the stack. Should there be any places to be fitted on the inside of the stack the methods shown in Figs. 580 and 583 are to be employed. Start fitting at the forward end of the stack and continuing to the aft end.

11. Finish fitting angles pc. mk. 17 and 18 to plates as shown in Figs. 580 and 583.
12. Fit base angle pc. mk. 20 to set marks on outside of No. 1 course at the bottom as shown in Fig. 581.

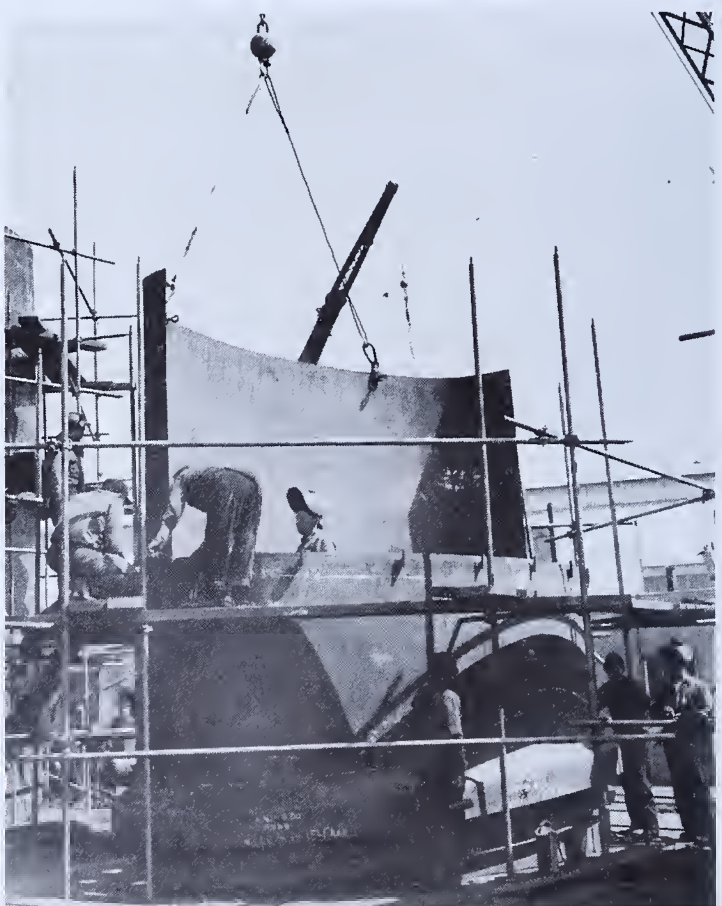


FIG. 577 — *No. 1 Course on Temporary Foundation*

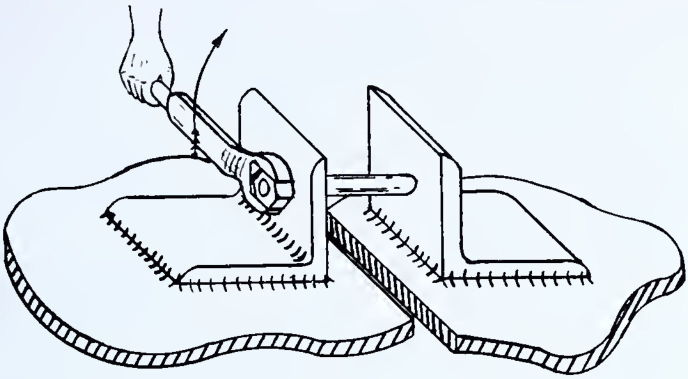


FIG. 578 — *Fitting Butt Joint with Angle Clips*

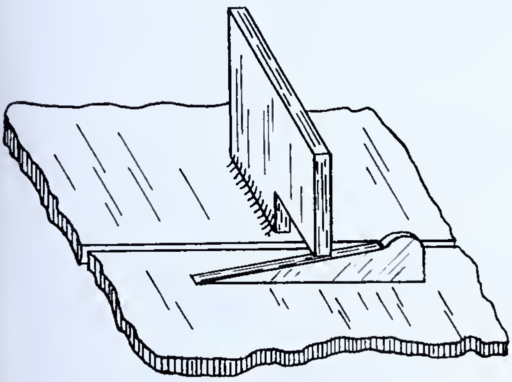


FIG. 579 — *Fitting Butts*

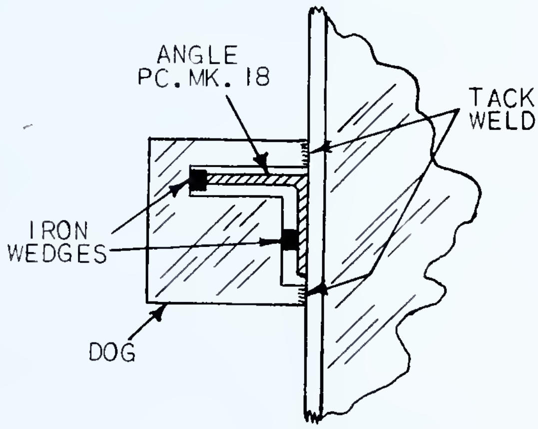


FIG. 580 — *Fitting Angle to Inside of Stack*

13. Burn out opening for stack door and holes for air hood as shown in Drawing 241-880-3.
14. Using 2″ x 2″ x ¼″ angle cut two pcs. 7′ 9″ long and one pc. 10′ long. Tack weld them to top of angle pc. mk. 18 in preparation for a flight of staging as shown in Fig. 582.
15. Have stage builders stage outside of No. 1 course in preparation for hanging No. 2 course.

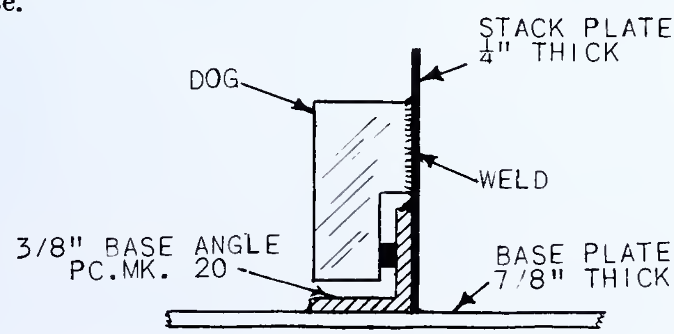


FIG. 581 — *Fitting Base Angle to Set Marks*

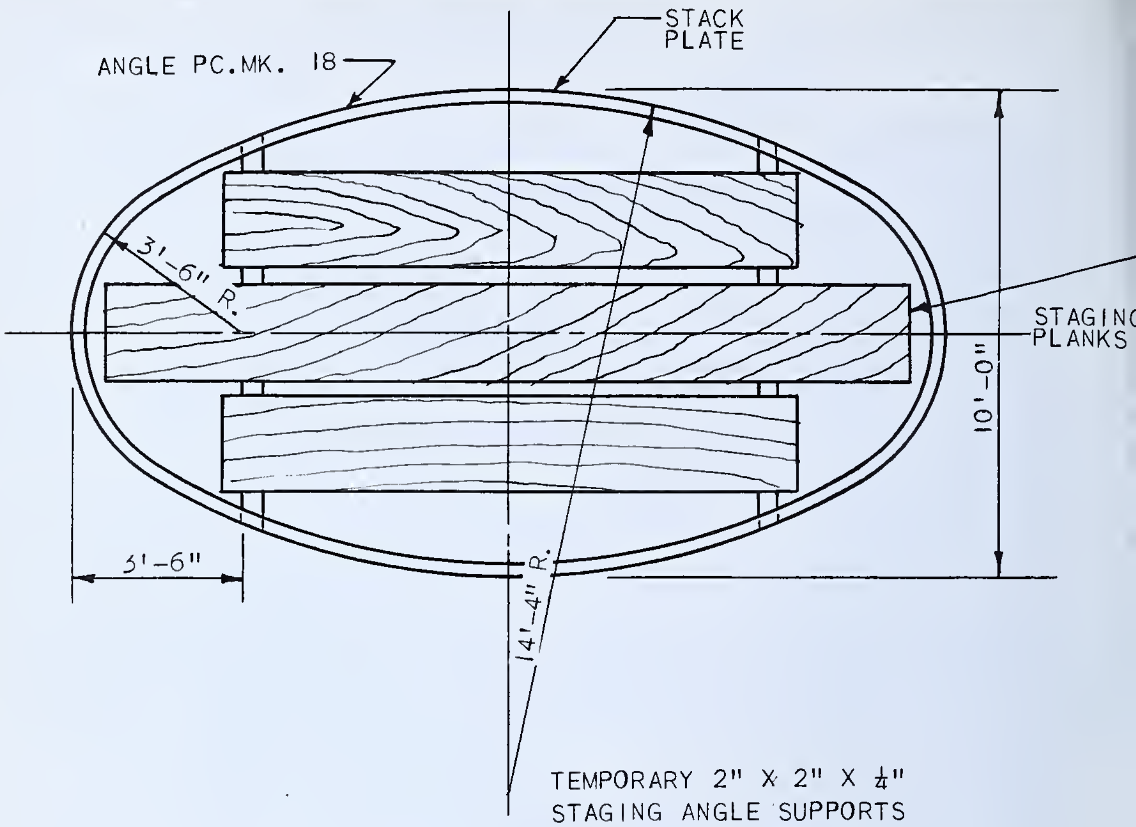


Fig. 582 — *Staging Inside of Stack*

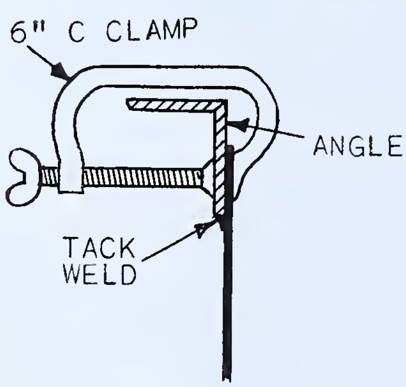


Fig. 583 — *Fitting Angles to Outer Stack*

16. Tack weld dogs to top of No. 1 course as show in Fig. 577 in preparation for hanging No. course.
17. With crane, hang No. 2 course starboard a shown in Fig. 577 and Drawing 241-880-3.
18. With plate still hanging on crane, fit No. course to No. 1 course as shown in Drawing 241-880-3 and 241-880-4 at section *g-g*.
19. Unhook crane and proceed with No. 2 cours port, as in Steps 17 and 18.
20. Have stage builders put up second flight of sta ing and fit forward vertical seam as explaine in Step 5.
21. Tack weld ¼″ x 3″ x 6″ pieces of flat bar as mentioned in Step 6 and with cran place angle pc. mk. 17 shown in Drawing 241-880-3.
22. Tack weld ¼″ x 3″ x 6″ pieces of flat bar as mentioned in Step 8 and with cran place angle pc. mk. 16 as shown in Drawing 241-880-3 and Fig. 584.
23. Fit aft vertical seam and angles as explained in Steps 10 and 11.
24. Place flight of staging on top of angle pc. mk. 16 as shown in Fig. 582.
25. With crane, hang No. 3 course port and starboard and proceed as in Steps 1 to 23 as shown in Drawing 241-880-3.

26. With crane, hang No. 4 course port and starboard and continue as in Step 21 and Step 23 as shown on Drawing 241-880-3.
27. Fit pc. mk. 24 to top inside edge of No. 4 course.
28. Fit air hood to No. 1 course as shown in Fig. 577 and Drawing 241-880-4 at section *J-J*.
29. On inside of stack, fit flat-bar stiffeners pc. mk. 21 and 22 as shown in Fig. 586, Fig. 587, Drawing 241-880-3 and Drawing 241-880-4 at section *F-F*.

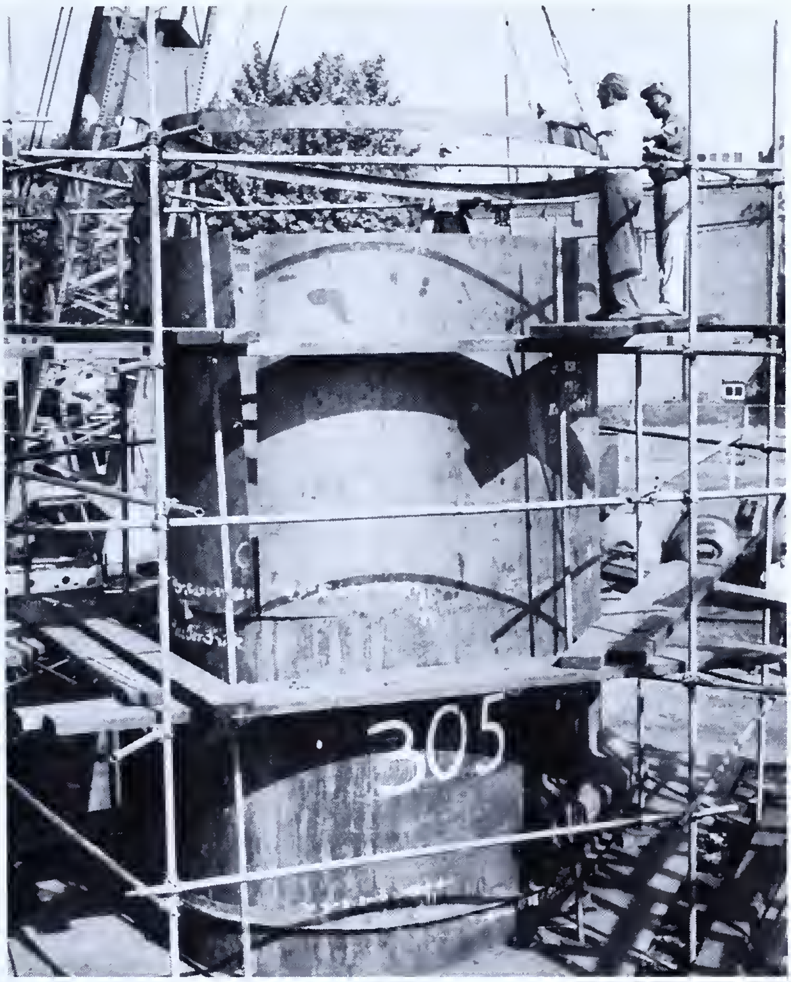
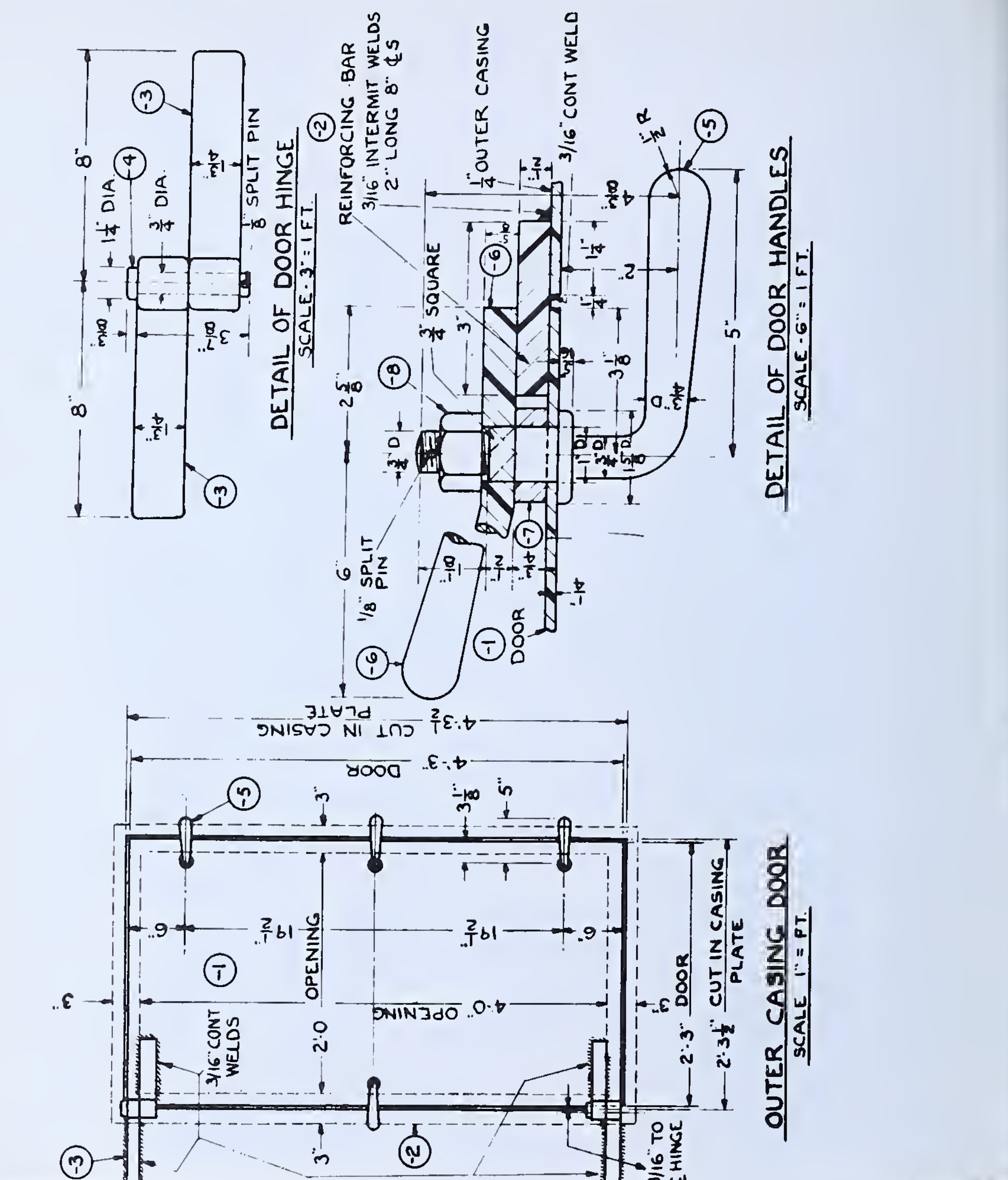


FIG. 584 — *Installing a Curved Angle in a Smoke Stack*

30. Fit whistle box and whistle brackets as shown in Fig. 587, Drawing 241-880-3 and Drawing 241-880-4 at section *H-H*.
31. Fit stack door as shown in Drawing 241-880-3 and Fig. 585.
32. Now weld the outer stack inside and out according to specifications.
33. When butts are welded on the outside, flush them off with a pneumatic chipping hammer, as shown in Fig. 588. Grind them smooth with a pneumatic grinder.
34. Burn off bottom of stack flush with base angle and block up.

Paint inside and out; remove staging inside and out, and outer stack is ready to be transported to its final point of assembly.



4	-8	3/4" STD HEX NUTS	STEEL			[illegible]
4	-7	WASHERS, 1 5/8" O.D. 1 1/32" I.D.	-	1/2" THK		"
4	-6	DOG HANDLE	F.S	DIE #75		240-32-07[illegible]
4	-5	DOOR "	F.S.	DIE #28		240-32-08[illegible]
2	-4	HINGE PIN	STEEL			0-880-01
4	-3	DOOR HINGE	F.S	DIE #26		240-32-08[illegible]
15 FT	-2	3" × 1/2" BAR	STEEL		DOOR OPENING REINFORCE.	0-880-0[illegible]
1	-1	PLATE 27" × 51" × 1/4"	"		DOOR IN OUTER CASING	"
1	2	OUTER CASING DOOR	COMPLETE		TO OTHER HAND	"
1	1	" " "	"		AS SHOWN	"
No Pcs.	Pc No	NAME OF PART	MAT'L	PATT. NO.	REMARKS	DR. NO.

1", 3", 6" = 1 FT.

OUTER CASING DOOR
OF SMOKE STACK

FIG. 585 — *Details of Stack Door*

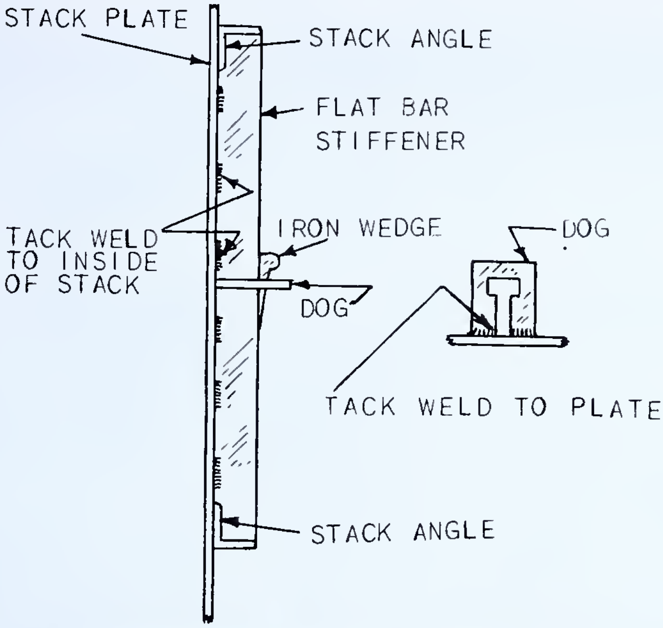


FIG. 586 — *Fitting Flat-Bar Stiffeners*

FIG. 587 — *Fitting Whistle Box and Brackets*

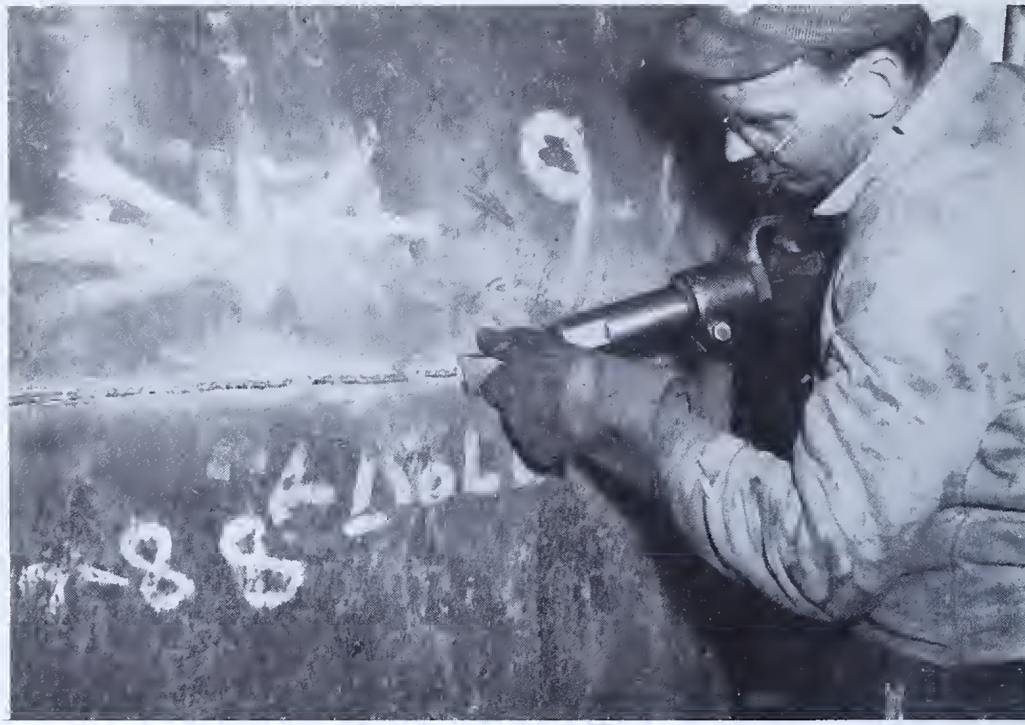


Fig. 588 — *Chipping Butt Welds Flush with Stack Surface*

Begin Erecting the Inner Stack at this Point

35. Fit together No. 1, 2, 3, and 4 courses of inner stack as shown in Fig. 589 Drawing 241-880-3 and Drawing 241-880-4.
36. Fit top angle and bottom angle (pc. mk. 19 and 20) as shown in Fig. 590.
37. Fit lifting pads and reinforcing pads as shown in Fig. 589 and Drawing 241 880-4, at section *C-C* at top of inner stack.

Fig. 589 — *Inner Stacks with Lifting Pads in Position*

38. Fit $\frac{1}{4}''$ x 3″ flat-bar stiffeners to set marks on outside of inner stack, as shown in Fig. 586 and Drawing 241-880-3.
39. Have inner stack welded according to specifications.
40. Remove any fitting dogs or clips; paint and transport to final point of stack assembly.

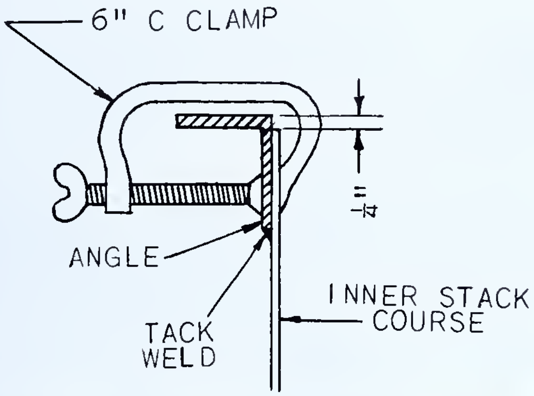


Fig. 590 — *Fitting Angles to Inner Stack*

Fig. 591 — *Fabricating a Stack Canopy*

Begin Erecting the Canopy at this Point

41. With crane, place two canopy diaphragm plates on a level foundation and fit together as shown in Figs. 591 and 592.
42. Fit canopy apron plates to diaphragm as shown in Fig. 592 and Drawing 241-880-4 at section *C-C* and *D-D*.
43. Fit 3″ half round (pc. mk. 30) to outer edge of apron plates as shown in Fig. 591, Fig. 593, Drawing 241-880-3 and Drawing 241-880-4 at section *D*.

44. Fit flat-bar stiffeners (pc. mk. 23) to set marks on inside of canopy as shown on Drawing 241-880-3 and Drawing 241-880-4 at section *D-D*, using method shown on Fig. 586 and Fig. 592.
45. Burn out manhole in the inner stack, remove any fitting dogs or clips, and turn the job over to the welding department to be welded on the inside.
46. When the welding is done, have crane turn canopy over, gouge out with pneumatic chipping hammer, gouge-chisel all butts, and fit manhole cover as shown on Drawing 241-880-3 and Drawing 241-880-4 at section *X-X*.
47. Have canopy welded according to specifications; then have it painted and transported to the final point of assembly.

FIG. 592 — *Fitting Canopy Apron Plates*

ASSEMBLING OUTER STACK, INNER STACK AND CANOPY

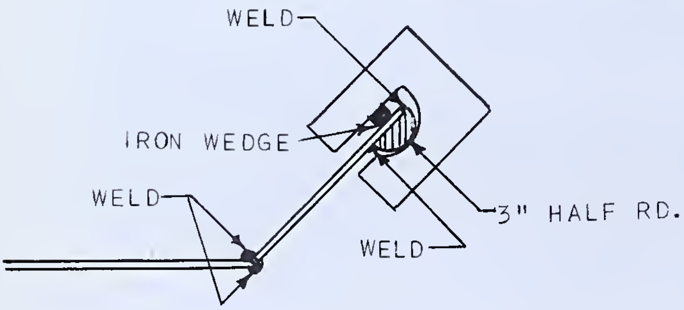


FIG. 593 — *Fitting Half-Round to Apron Plates*

48. With a template made by the boilershop layout man, lay out the casing top as shown in Drawing 241-880-3 plan at casing top.
49. With crane, place outer stack on casing top on center lines provided and unhook crane.
50. Fit base angle on bottom of No. 1 course to set marks on casing top as shown in Fig. 594 and Fig. 595.
51. Burn out hole in casing top for inner stack.
52. With crane, place inner stack inside outer stack on center lines provided as shown in Drawing 241-880-3.
53. Fit base angle of inner stack to set marks on casing top, using method shown in Fig. 595.

54. Place and fit inner-stack guide angles and inner-stack guides as shown on Drawing 241-880-3.
55. Fit angles for grating support as shown on Drawing 241-880-3.
56. With template made by the boilership layout man, make a jig for assembling gratings as shown in Fig. 596.

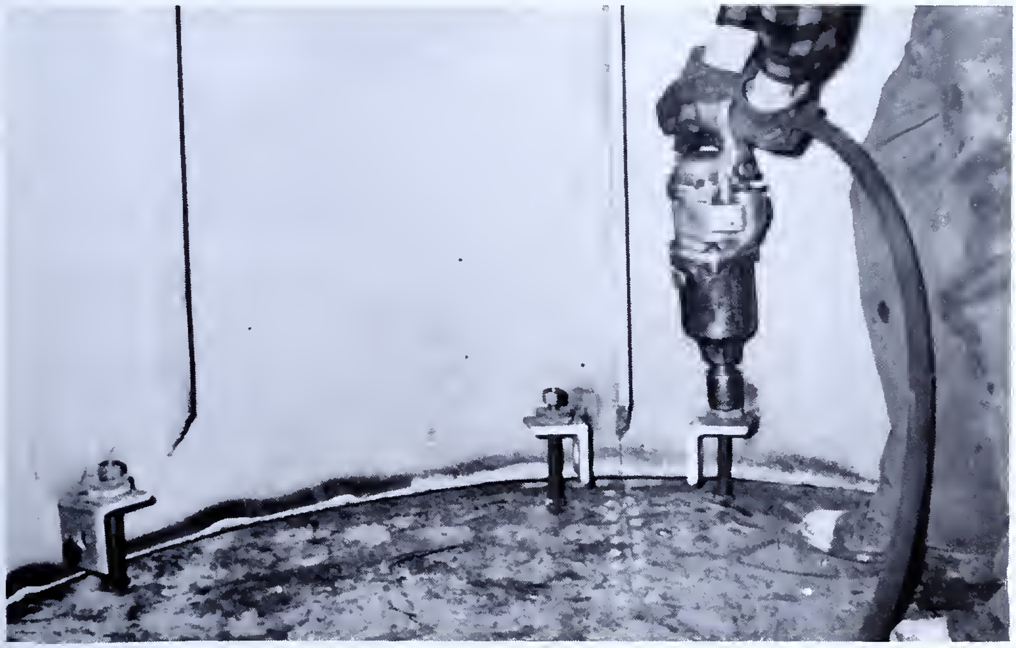


FIG. 594 — *Tightening Stack to Base with Impact Wrench*

57. Place flat bar on edge against heel of angle clips and tack to jig.
58. Place two strips of wood the correct height as shown in Fig. 596.

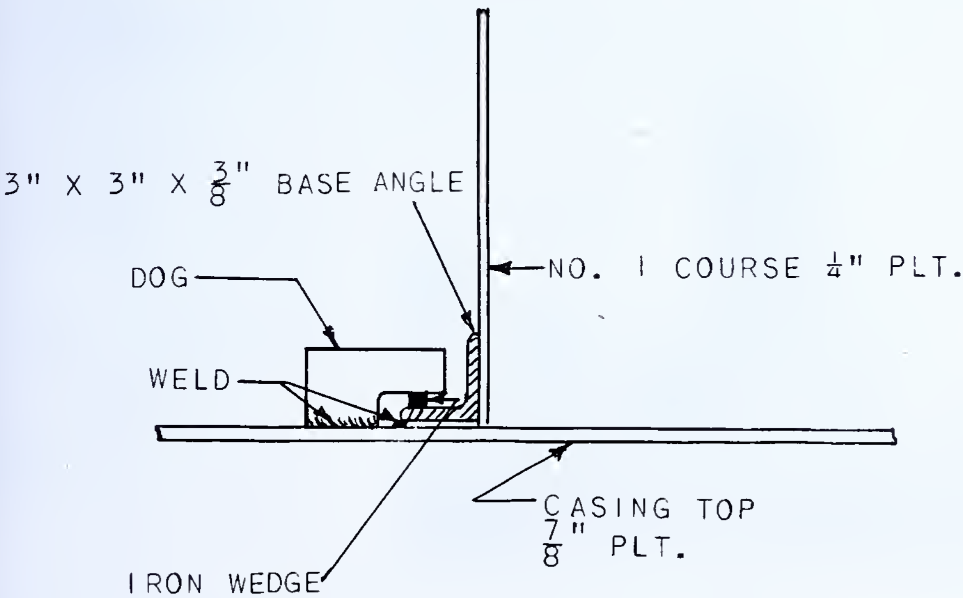


FIG. 595 — *Fitting Base Angle*

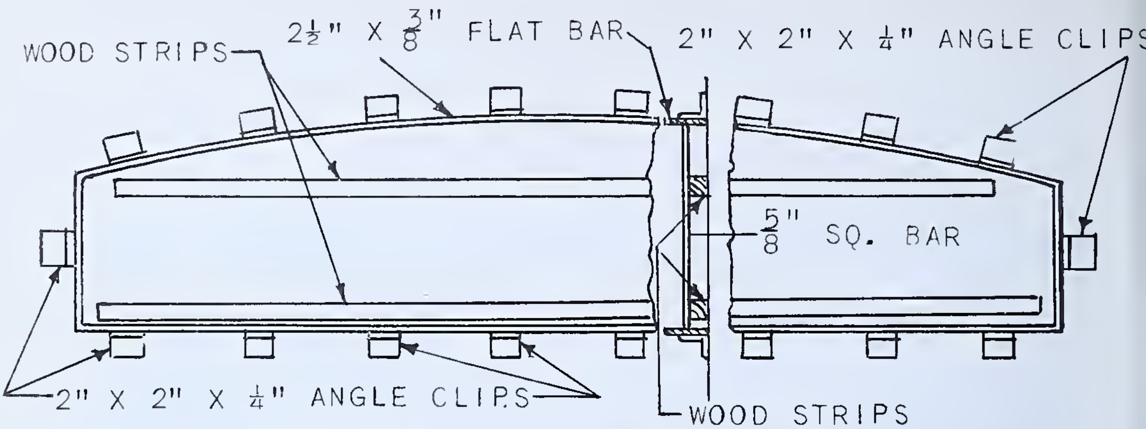


FIG. 596 — *Jig for Assembling Gratings*

59. Place grating bars previously cut to correct size on top of wooden strips and over set marks seen in Fig. 596 and weld.
60. Continue with other pieces of grating differing only in size and shape in the manner explained in Steps 51 to 54. Make a different jig for each piece of grating.

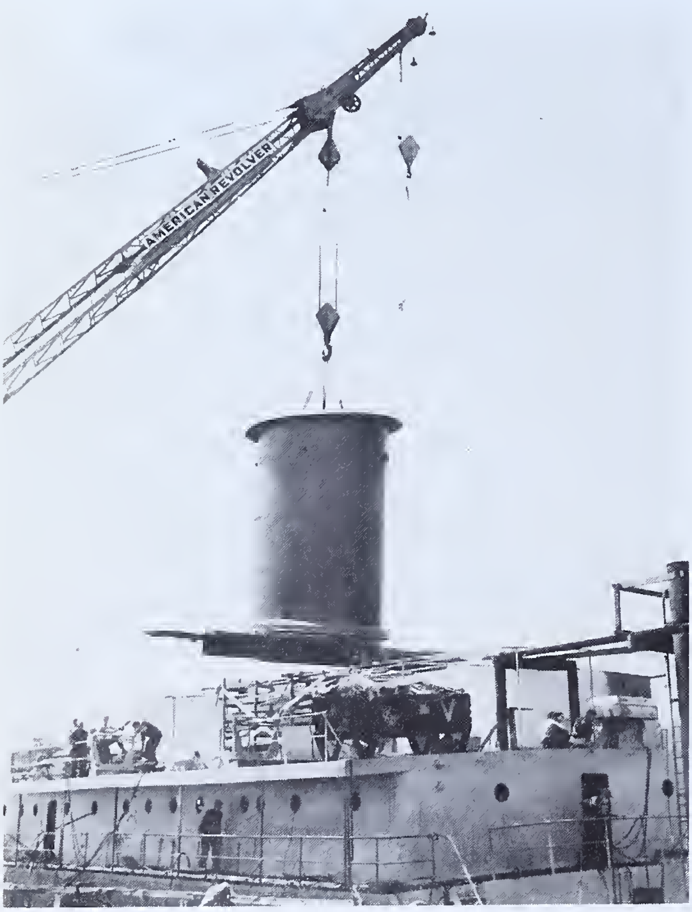


FIG. 597 — *Landing a Finished Smoke-Stack Aboard Ship*

61. With crane, place grating on angle supports as shown on Drawing 241-880-3. Unhook crane.
62. With crane, place ladders shown on Drawing 241-880-3. Unhook crane.
63. Fit ladders to stack as shown on Drawing 241-880-3 and Drawing 241-880-4 detail of ladder support.
64. Fit to top sides on inner stack the canopy brackets shown on Drawing 241-880-4 in sections *C-C* and *E-E*.
65. Have machinists place and bolt down whistle.
66. With crane, place canopy on top of inner stack and canopy brackets as shown on Drawing 241-880-3.
67. Unhook crane, and fit canopy to canopy brackets and angle on top of inner stack.

68. Fit flanged canopy brackets to canopy and guy pads, and fit antenna pads to outside of outer stack.
69. Fit whistle ring to whistle box, and weld heads of bolts to whistle box on outside of stack as shown on Drawing 241-880-4, section *H-H*.
70. Have coppersmiths fit fairweather around whistle.
71. Weld stack according to specifications.
72. Remove any fitting dogs or clips and staging from inside of stack.
73. Have painters cement all seams on outside of outer stack, and paint the entire stack according to specifications.
74. Have stage builders remove staging from outside of stack.
75. Prepare to have the stack go aboard ship. (Fig. 597 shows the landing of a finished smokestack aboard ship.)

QUESTIONS

1. **What is the purpose of a smokestack?**
2. **What is understood by the "rake" of a smokestack?**
3. **Why is the inner stack supported independently from the outer stack?**
4. **Explain the meaning of the phrase "course of a stack."**
5. **How is the inside of the outer stack staged?**
6. **Describe the method of fitting the No. 1 course.**
7. **How many courses are used to make the inner stack?**
8. **For what purpose are the lifting pads on the inner stack?**
9. **Describe the method of laying out a base plate or fidley top with the aid of a template.**
10. **Describe the procedure for fitting the outer stack to the fidley top.**
11. **How many separate pieces of grating are used in a stack?**
12. **When the inner stack is placed inside of the outer stack should the longer length of the inner stack be placed forward or aft?**
13. **Explain how the canopy is supported.**
14. **Describe a fairweather.**

JOB SHEET NO. 44
TO INSTALL A SEA CHEST

General Information

A sea chest is a recess or space built into the hull of a ship for the purpose of taking aboard or discharging sea water. The sea chest shown in Drawing 241-901-20 is the 26″ upper, main, sea-suction unit.

It is fitted with a strainer plate on the outside to keep foreign objects from getting into the chest. If this condition does arise, however, the chest is equipped with a steam blow to be used to clear it of any foreign matter which becomes lodged behind the strainer plate.

Sea chests are usually located below the water line of the ship and constitute a part of the ship's hull. The holes in the hull are located and burned out by the shipfitters. The plates (which constitute the sea chest) of the correct thickness are laid out, burned, and flanged in the boiler shop. The boilermakers install the sea chest on the ship.

Reference—Drawing 241-901-20 is in the back of the book. Use it as a reference for the study of this job sheet.

Tools and Equipment

1. 1½-lb. ball-peen hammer
2. Pneumatic chipping hammer
3. Side-cutter chisels
4. Chalk line
5. 12″ square
6. 6′ folding rule

Materials

Chalk Soapstone

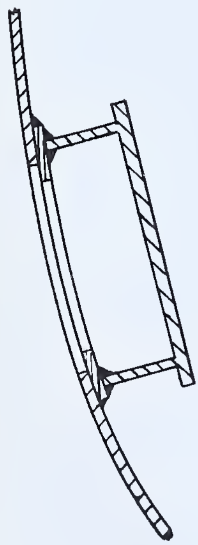


Fig. 598 — *Typical Sea Chest*

Procedure

1. Place pc. mk. 2 (support ring) on inside of hull, and center it on hole cut in shell as shown on Drawing 241-901-20 in *B* at sections *A-A* and *B-B*.
2. Fit, support with clips (Fig. 600), dog ring to shell (Figs. 599 and 600), and tack weld as shown in Fig. 599.

   This ring should be tacked with 3″ tacks on 12″ centers and welded in place according to specifications before continuing with the remainder of the chest.
3. Place and fit pc. mk. 12 (top plate) and pc. mk. 11 (bottom plate) as shown on Drawing 241-901-20 at *A*. In fitting these plates, the shell should not be fitted to the plates; the plates must be fitted to the shell. Any attempt to fit to the plate will not only be very difficult; it will also distort the shell plates. Fig. 601 shows method of marking off top and bottom plates so they will fit shell correctly.

4. Place end plate (pc. mk. 10) as shown on Drawing 241-901-20 at *E*.

   The plate must fit between longitudinals 12 and 9 as shown. It will be noted that this plate cannot be placed without either cutting the plate or cutting the flange on the longitudinal. Cut the flange on the longitudinal.

5. Mark off pc. mk. 10 as explained in Step 3, Fig. 601.
6. Fit pc. mk. 10 to shell and top and bottom plates as shown in Drawing 241-901-20 at *E*.
7. Continue with pc. mk. 8. Consult Drawing 241-901-20 at *E* as in Steps 2 to 6. Place and fit front plate, pc. mk. 9, between pcs. mk. 5 and 8 and on top edge of top and bottom plate as shown on Drawing 241-901-20 at sections *A* and *E*.
8. Fit pieces of longitudinal removed in Step 4.
9. Turn the sea chest over to the welding department for welding according to specifications and then to the outside machinist for fitting strainer plate, spool, and nozzles.

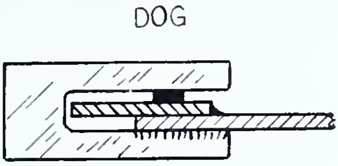


FIG. 599 — *Arrangement of Dog and Iron Wedge*

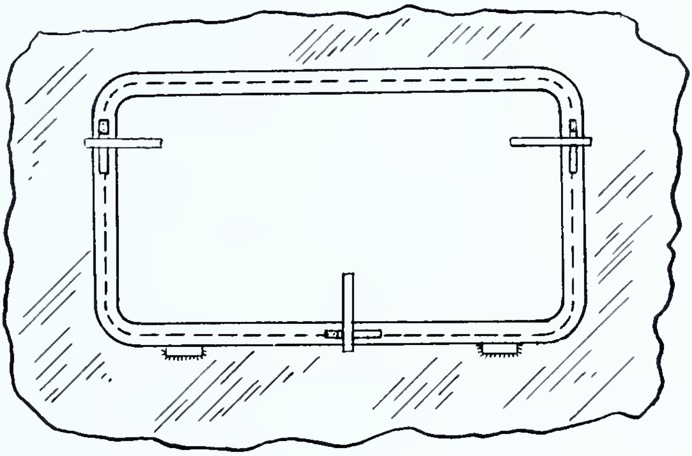


FIG. 600 — *Support Ring Dogged in Place*

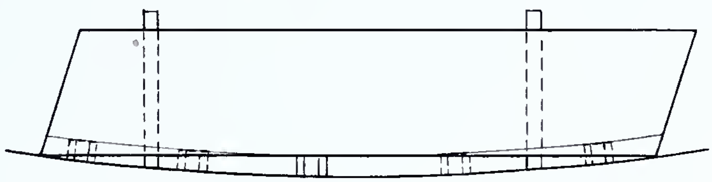


FIG. 601 — *Fitting the Plate to the Shell*

QUESTIONS

1. **What is the purpose of a sea chest?**
2. **Why is the sea chest fitted with a strainer plate?**
3. **What is the purpose of the steam blow?**
4. **Explain method of fitting the support ring. Refer to Drawing 241-901-20 and Fig. 599.**
5. **How is the shape of the hull transferred to the sea-chest plates without the use of a template?**
6. **Why cut the flange on the longitudinal instead of the end plates?**
7. **From what source is the correct thickness of the sea-chest plates obtained?**

APPENDIX I

BOILERMAKING TERMS AND DEFINITIONS

A

Access Hole — A hole through casing, bulkhead, floor or deck to enable one to reach work or gear.

Accommodation Ladder — Stairs slung at the gangway.

Aft, After — Toward the stern or rear of ship. Between the stern and the amidship section of a vessel.

After Perpendicular — A vertical line at right angles to the base line at a point designated by the naval architect.

Air Casing — A ring-shaped plate coaming surrounding the stack and fitted at the upper deck, just below the umbrella. It protects the deck structure from heat and helps ventilate the fire room.

Angle — The point where two lines meet. Sometimes used as a shorter term for angle iron.

Angle Bar — A bar "L" shaped, or two flanges at 90 degrees.

Angle Clip — A piece of angle iron used to fasten one part of a ship's structure to another.

Angle Collar — Circular angular section fastened around a column to hold the column to the deck.

Assemble — To collect or put into place different parts.

Auxiliary Foundations — The supports for pumps, condensers, distillers, etc.

B

Base Line — A horizontal level line at the lowest point of the mold lines and the top of the keel plate.

Batten — A narrow strip of wood for fairing lines. Also a strip of wood to fasten objects together.

Bitts — Iron heads fixed on any deck, for belaying of hawsers, warps, ropes, etc.

Boiler Casing — A wall protecting the different deck spaces from the heat of the boiler room.

Boiler Room — The part of the ship where the boilers are placed, connected with boiler hatch to top deck.

Bolster Plate — A piece of plate adjoining the hawse hole, to prevent the chafing of the hawser against the cheeks of a ship's bow. A plate for support like a pillow or cushion.

Booby Hatch — The cover of a scuttleway or small hatchway such as that which leads to the forecastle or forepeak.

Boom, Cargo — A boom extending from the mast like a derrick arm. It is used to handle cargo.

Boom Rest — A saddle in which the boom is lashed down and made fast.

Bosom — The inside of an angle bar.

Bosom Bar — An angle bar of sufficient length to connect the ends of two angle bars, usually three rivet holes on each side, fitting in the bosom or inside of the angles.

Boss — Any protuberance on parts. For example: The boss on the stern casting is the part through which the propeller shaft runs.

Bounding Bar — An angle which surrounds a plate in a frame or a bulkhead to make connections. A shape connecting two plates.

Bow — The front or forward end of a ship.

Bow Plate — Any of the shell plates in the bow of a ship.

Bracket — A steel plate, commonly with a reinforcing flange, used to stiffen or tie beam angles to bulkheads, frames to longitudinals, etc.

Buckled Plate — A plate warped in or out, making it out of line; a plate thicker at the center than at the edges.

Bulb Angle — An angle bar with its long leg terminating in a bulbed toe.

Bulkhead — A watertight partition extending from the double bottom to the top main deck, so constructed that in case of accident in one compartment, damage is confined to that compartment. A partition in a ship which divides the interior into various compartments.

Bulkhead (Longitudinal) — A partition wall of plating running in a fore-and-aft direction.

Bulkhead (Transverse) — A partition wall of plating running in an athwartship direction across a portion of the whole breadth of a ship.

Bunker — A compartment in which fuel is stored.

Butt Joint — A joint made by fitting two pieces squarely together on their edges, which is then welded or butt strapped.

Butt Strap — A plate to connect two plates or bars together at the ends.

C

Cargo Hatch — An opening in a ship's deck for the loading and discharging of any kind of cargo.

Cargo Port — A large opening in a vessel's side through which cargo is passed on and off.

Casing — The extra case or bulkhead built around the ship's funnel, engine room, or boiler room to protect the surrounding parts from heat.

Calk — To tighten a lap or other seam with a chisel.

Center Line — The fore-and-aft line at the middle of the ship.

Chalk Line — A small line, strong enough to withstand being drawn very taut over a surface. The line is first chalked then drawn taut between two points and "snapped", thus leaving an impression of the chalk on the surface to be marked.

Check Line — Used in shaping plates etc., to make sure that the templates have not changed in size by shrinking, expanding, or warping.

Chocks — Deck fittings for mooring lines to pass through.

Clip — Short length of bar, generally an angle, used to attach shapes to the ship structure.

Cofferdam — A void or empty space separating two or more compartments to prevent water from entering another compartment in case of a leak.

Collar — An angle ring used around a pipe or mast, or a flat plate made to fit around a girder or beam passing through a bulkhead or deck. It serves to make various spaces watertight, oiltight, weathertight, or dusttight.

Countersink — A hole tapered so that a rivet, bolt, or screw head will come flush with the surface of the material.

Cradle — Frames used during construction of a ship conforming to the curvature and shape. They are generally made of flat bars and shapes and support the shell until the shell is tied in the bulkheads and framing.

Cribbing — Timbers used to support bottom of ship while it is under construction.

Crosstree — A structure on the mast built up of plates and angles for the purpose of holding the shroud pads.

D

Deck — A deck in a ship corresponds to the floor in a building. Decks are named or numbered by the architect designing the ship and bear these names and numbers from that time on.

Deck Beam — A beam which supports a deck.

Deck, Hurricane or Boat Deck — The uppermost deck; deck where boats are stowed.

Deck Plan — A drawing showing the layout of a deck.

Distortion — The result of excessive strains that cause a plate or a form to lose its proper shape.

Dogs — Holding devices used on doors, hatch covers, air ports and other hinged parts of a ship.

Donkey Engine — An auxiliary engine to operate the lifting apparatus on deck.

Doubler Plate — An extra plate of the same strength or stronger than the original plating for additional strength.

Drift Pin — A small tool used to draw adjoining parts in line so that the rivet holes will coincide.

Dry Dock — A dock into which a vessel is floated, which when raised lifts the boat out of the water.

E

Engine Room — Where the engines of a ship are confined, next to the boilers.

Erection — The process of hoisting into place and bolting up the various parts of the ship's hull, machinery fittings, etc.

F

Fabricate — To shape, assemble, and secure in place the component parts in order to form a complete whole. To manufacture.

Fairwater — A term applied to plating fitted in the shape of a frustum of a cone, around the ends of shaft tubes and struts to prevent a change in the stream lines. It is also found at ends of heavy steel armor.

Fathom — Six feet; a marine unit for measuring depth.

Fidley Deck — A partially raised deck over the engine and boiler rooms, always round the smokestack.

Fillet — Where two surfaces meet, forming a corner, any material in the corner to partially fill it is a fillet. Usually the fillet is concave.

Flange — The turned edge of a shape or plate, which acts to resist bending strain.

Flare — The spreading out from the central vertical plans of the forebody of a ship with increasing rapidity as the section rises from the water line to the rail; to spread the projection of a boiler tube, flaring and expanding generally being done in the one operation.

Flat — A term applied to a partial deck built without any camber.

Flush Head Rivet — A rivet, the head of which does not extend above the surface of the plate, angle bar, etc., in which it is driven.

Fore and Aft — In line with the ship's keel; fore and aft deck line girders.

Fore, Forward — Toward the stem or front. Between the stem and amidships.

Frames — The ribs of a ship.

Frame Angle Bars — The angle bars of which a frame of any kind is constructed.

Frames Spacing — The distance between frames.

Funnel — A large sheet iron tube, extending from the uptake high above the deck, through which the smoke and gases pass.

Furnaced Plate — A plate that requires heating in order to shape it as required.

G

Galley — The kitchen of a vessel.

Galvanizing — The process of coating one metal with another, ordinarily applied to the coating of iron or steel with zinc. The chief purpose of galvanizing is to prevent corrosion.

GANGPLANK — A board with cleats, forming a bridge reaching from a gangway of a vessel to the wharf.

GANGWAY — The opening in the bulwarks of a vessel through which persons come on board or disembark. Also a gangplank.

GEAR, STEERING GEAR, RUNNING GEAR, CLEANING GEAR, etc. — A comprehenhensive term used in speaking of all the implements, apparatus, machinery, etc., which are used in any given operation.

GIB — A metal fitting that holds a member in place, or presses two members together.

GIRDER — A heavy supporting beam.

GOOSENECK — A return, or 180 degree bend, having one leg shorter than the other. An iron swivel making up the fastening between a boom and a mast. It consists of a pin and an eyebolt, or clamp.

GRATING — An open iron lattice work used for covering hatchways and for forming a platform in engine room, stair landings, etc.

GROMMET — A ring of candle wicking used as a washer or gasket around bolts and studs to make a watertight joint.

GROUNDWAYS — Stationary timbers, or tracks, laid on the ground or foundation cribbing, upon which the sliding timbers of ways (supporting a vessel to be launched) travel.

GUSSET PLATE — A tie plate, used for fastening posts, frames, beams, etc., to other objects.

GUYS — Wire or hemp rope or chains to support booms, masts, davits, etc.; guys are employed in pairs. Where a span is fitted between two booms, for example, one pair only is required for the two.

H

HEADER — A bar or angle under a deck the same size as deck beams. It is used around stair openings in deck, small hatch openings, or at the dead end of longitudinals; a manifold, or section into which tubes are expanded.

HEEL — The intersecting point or corner of the web and flange of a bar.

HOLD FAST — A dog or brace to hold objects rigidly in place.

HULL — The body of a vessel, not including its masting, rigging, etc.

I

I BEAMS — Steel beams with cross section like the letter I.

INBOARD — From the side to the center of ship.

INTERCOSTALS — Plates which fit between floors, frames, or beams, as stiffeners.

J

JACK LADDER — A ladder with wooden steps and side ropes.

JACOB'S LADDER — A rope ladder with wooden rounds.

JOGGLE — To lap a joint by keeping one edge straight and bending the other in order to leave both surfaces even on one side. An offset in a plate, the depth of which is equal to the thickness of the plate forming the lap end that is not offset.

K

KNEE — An angle or channel from deck beam to shell frame taking the place of a bracket.

KNOT — A measure of speed; if a ship travels in one hour a distance of 6,080.26 feet, it is said to be going at a speed of one knot per hour. A knot is a speed of 1.15156 statute mile per hour. A ship traveling 10 knots per hour is covering 11.5156 land miles per hour.

L

LADDER — Inclined or vertical steps on board ship taking the place of "stairs".

LANDING — The distance from the edge of a plate or bar to the center of the first rivet hole.

LANDING STAIRS — Tread on stairs enlarged to form a platform.

LAP — A joint in which one part of a plate overlaps another, thus avoiding the use of a butt strap.

LAYING OFF — Marking plates, bars or shapes for shearing, punching, bending, and identification from a template or print.

LAY OUT — To develop on a working surface, lines to their true dimensions.

LIFTING — Transferring marks, shapes, and measurements from a ship drawing, or model, to a plate or other objects, by means of templates.

LIFT A TEMPLATE — To construct a template to the same size and shape as the part of the ship to be duplicated.

LIFT FROM THE HULL — As a rule, templates are made for most plates and bars, but sometimes it is necessary to "lift" by placing a frame of wood around the opening for the missing plate, and when nailed, to transfer the holes of the adjoining plates by pencil mark, and when a sufficient amount of landing has been given, the plate should be the proper size.

LINER — A piece of flat steel which may or may not taper to a feather edge. Used to fill out a lap or to form a middle layer between two objects. Also for leveling foundations.

LOCKER — A storage compartment in a ship.

LOFTSMAN — A man who lays out the ship's lines in the mold loft and makes the molds and templates.

LONGITUDINAL — A bulkhead, frame, or longitudinal stiffener, running fore-and-aft.

M

MANHOLE — A hole in a tank, boiler or compartment on a ship, designed to allow the passage of a man to examine, clean, and repair.

MAST — A hollow steel pipe or tube made up of plates and doublers tapering smaller at the top, placed on the center line of the ship.

MIDSHIP — The vertical transverse section located at the mid point between the forward and after perpendiculars. Usually this is the largest section of a ship in area

MITER — To match angles; an angled cut made for a joint.

MOLD — A pattern or template. Also a shape of metal or wood over or in which an object may be hammered or pressed to fit.

MOLDED LINE — A working point, used to guide the structural alignment in accordance with the design.

MOLD LOFT — The large enclosed floor where the lines of a vessel are laid out and where the molds or templates are made.

MUSHROOM VENTILATOR — A short cast iron tube having a movable iron rod passing through its center. On top of the rod is fixed a round metal cup, which may be lifted to admit air or closed to prevent water entering the tube, usually fitted over cabins.

N

NEUTRAL CENTER — The plan which is the geometrical center of the thickness of a plate.

O

OFFSET — To bend out of line sharply. The points given by the draftsman to the loftsman for putting down lines.

ON BOARD — On or in a ship.

OUTBOARD — Used to designate from the center to the sides of a ship.

P

PANTING — The pulsation in and out of the bow and stern plating as the ship alternately rises and plunges deep into the water; the pulsation in and out of a boiler while steaming.

PITCH — The distances between the center of two contiguous objects, such as teeth of a wheel, etc.; also the distance a screw propeller would advance in one revolution if turning in a steadfast medium.

Platen — A flat working surface for layout and assembly work.

Plates, Diagonal — Plates fitted diagonally.

Platform — Plating joined horizontally, forming an elevated stand or flooring.

Play — The difference between the diameter of a shaft, rod, etc., and that of the hole in which it works.

Plug Weld — Welded to oblong holes in a plate that laps on another plate or casting.

Port Side — The left-hand side of a ship looking forward toward the bow or stem.

Prick Punch — A small punch with a keen point used to transfer the holes from the template to the plate.

Punched Rivet Hole — A rivet hole made by a punching machine.

Q

Quadrant — A nautical instrument, on the arc of which is a finely graduated scale showing degrees and minutes, with adjustable reflectors, etc.; used to find the altitude of heavenly bodies, angular distances, etc.; on a marine engine, quadrant bars are part of the reversing gear. On a steering gear, the rudder quadrant is a section of a wheel or sheave fastened to the rudder head. In mensuration, a quadrant is a quarter of the area of a circle measured with a 90° angle and the circle circumference.

Quadruple Riveting — The riveting together of parts by four rows of rivets.

Quicken — To shorten the radius of a curve; as, to quicken a sheer is to make it more pronounced.

R

Rabbet — An edge having material removed to accommodate other material to be applied on that edge.

Rack — A shelf, framework, etc., in which objects are secured to prevent them from moving about.

Rake — The inclination of a vessel's mast, funnel, stem, etc., from its upright angle with the keel. The rake may be either forward or aft. The elevation of the outer end of a bowsprit above the level of its inner end.

Rail — A guard made of flat pieces of wood, or steel bars or rods, joined, and connected to the upper edge of the bulwark plating, or fitted upon the summits of stanchions surrounding an upper deck, bridge, poop, or forecastle, etc.

Reaming — Using a reamer to make rivet holes fair and smooth on the inside.

Rigger — One whose occupation is to rig or unrig vessels, take up or down the yards, etc.

Rigging — Manila and wire ropes, lashings, etc., used to support booms, masts, spars, etc. Also, handling and placing heavy weights and machinery.

Rivet — A metal pin by which the plating and other parts of iron and steel vessels are joined. Rivets are known by their heads, such as: flush, pan, snap, plug, tap, countersunk, mushroom, and swollen neck.

Rivet Holes — The punched or drilled holes in plating, frames, etc., into which the rivets are driven for connection.

Riveting — To fasten with rivets.

Roller Chocks — Chocks with a short vertical roller fixed to ease a line passing through.

Row of Rivets — A continuous line of rivets.

S

Scarph — (Also spelled scarf.) A lapped joint made by beveling off, or otherwise cutting away the sides of two plates at the ends.

Screen Bulkhead — An arrangement to prevent the cold air from striking the boilers directly.

Seam — The line where the edges of plates meet when joining each other.

Section — A drawing representing the internal parts of a vessel as if she had been cut straight through either longitudinally or athwartships.

Sheer — The upward curvature of the lines of a vessel toward the bow and stern.

Shell — The outside plating of a ship from stem to stern.

Shell Doubling or Doubler — An extra plate added to strengthen the shell.

Shell Plating — The plating forming the outer skin of a vessel.

Shim — A piece of metal or wood placed under the bed-plate or base of a machine or fitting for the purpose of truing it up.

Shipfitter — A mechanic who makes templates, marks, assembles, and fastens in place plates and shapes for the hull of a ship. Should be able to do any fitting on ship.

Shore — One of the many wooden props by which the ribs or frames of a vessel are externally supported while building, or by which the vessel is held upright on the ways.

Shoring — The act of supporting anything by shoring it up.

Shroud Pads — Devices for attaching shrouds or guy cables to crosstree and bulwark.

Skylight — A framing of metal fitted over an opening in a deck, with window glass inserted for the admission of light into a cabin, engine room, etc.

Soft Patch — A plate put on over a break or hole, and secured with stud bolts. It is made watertight with a gasket such as canvas saturated with red lead.

Spacing of Rivets — The distance from the center of one rivet hole to the center of the next, depending on the diameter of the rivets and the purpose for which they are employed.

Spar — A pole used for a hoist or in scaffolding.

Spot-Faced — Indicates that an annular facing has been made about a bolt hole to allow a nut or head to seat evenly.

Stage — A platform of boards or planks, hung in ropes or otherwise supported for a person to stand upon when cleaning, scraping, or painting the outside or inside of a vessel.

Starboard Side — The right-hand side, looking from aft forward.

Stays — Bars used for binding or supporting or holding parts together.

Stern — The after or rear end of the vessel.

Stiffener — An angle bar or stringer fastened to a surface to strengthen it and make it rigid.

Strong Back — A bar for locking cargo port doors and watertight scuttles.

Strong Back — A portable beam to hold hatch covers and deck loads.

Strong Beam or Trolley Beam — A portable beam over engine and boiler-room space in the engine and boiler-room casing carrying a traveling hoist.

Strut — Strips of flat iron used to brace one part with another.

Superstructure — Any structure built above the top full deck, such as a deck house, bridge, etc.

Swash Bulkheads — Longitudinal or transverse bulkheads fitted in a tank to decrease the swerving action of the water. Their function is greatest when the tanks are partially filled. Without them the unrestricted action of the liquid against the sides of the tank would be severe.

Swash Plate — A plate fitted in a tank to retard the flow or surge of liquid cargo or ballast when the ship rolls or pitches.

Symbols — Marks of identification.

T

TANKS — Are of two kinds: First, those built-in permanently and part of the ship's structure, used for the reception of water ballast, fuel oil, or liquid cargo; second, those of special construction, removable if necessary. These vary greatly in size and shape and the purpose for which used.

TANK TOP — The plating laid on the floors of a ship, which forms the top side of the tank sections or double bottom.

TANK VESSEL (TANKER) — A vessel specially constructed and equipped with tanks for carrying liquids in bulk.

TAP — To cut threads inside of a hole. A tool for tapping.

TEE IRON, TEE BAR — Bar iron with cross section like the letter T.

TEMPLATE — Patterns made in the mold loft from wood strips, cardboard, or heavy paper.

TIPPING BRACKETS — Flat bar or plate brackets placed at various points on deck girders, beams, stiffeners, or longitudinals as reinforcement.

TOE — The edge of a flange on a bar.

TRANSVERSE BULKHEAD — A bulkhead placed athwartships.

TRIPLE RIVETING — To fasten by three rows of rivets.

TURBINE — A form of engine in which all driving parts rotate. There are various types in marine use.

TURNBUCKLES — Used to pull objects together. A link threaded on both ends of a short bar, one left-handed, the other right-handed.

U

UMBRELLA — A metal shield in the form of a frustum of a cone, fitted to the outer casing of the smokestack over the air casing to keep out the weather.

UPTAKE — The part connecting smoke box to funnel. Sometimes the term is used to include the smokebox.

V

VENTILATOR — A device for furnishing fresh air to compartments below deck or for exhausting foul air.

W

WAKE — The motion of water left by a moving ship.

WAYS — The frame work of timber, etc., on which a vessel is built, and from which she is launched into the water.

WEB — The plate or its equivalent in a beam or girder, which connects the upper and lower flat plates, or laterally extending members.

WEDGES — Tapered pieces of wood or iron, used extensively to force parts into place.

WEEPING — When water oozes through the seams of a vessel's shell, or a steam boiler, etc., they are said to weep.

WELDING — Connecting two separate pieces of steel, iron or other metal with a gas flame or an electric arc, so that they become all one piece.

WINCH — A machine used for loading and discharging cargo, or for hauling in lines.

APPENDIX II

ABBREVIATIONS USED BY BOILERMAKERS

AE — After end (rear or stern)
ALT — Alteration
AMM — Ammunition
Ls — Angles or angle bar
A.P. — After Peak
A.P. — After perpendicular
AUX — Auxiliary
B.A. — Bulb angle
BEV — Bevel
B.L. — Base line
B.M. — Bolted manhole cover plate
B/M — Bill of material
B.O.S. — Bevel other side
BOT — Bottom
BHD — Bulkhead
BTK — Buttock
B.T.S. — Bevel this side
C.D. } Cofferdam
COFF }
CEM — Cement
C — Channel or channels
CIR — Circumference
CL or ℄ — Center line
COAM — Coaming
CK — Countersunk
CSK — Countersink holes
CSK — OS — Countersink other side
COMP'T — Compartment
COND — Condenser
CONN — Connection
C. to C. — Center-to-center
C. to E. — Center-to-end
C.R.C. — Closed roller chock
C.T.C. — Closed towing chock
CTRS — Centers
C.V.K. — Center vertical keel
DBLR — Doubler
DEG — Degree
DET — Detail
DIA. & D. — Diameter
DIM — Dimension
DK — Deck
DR — Door
DR — Drill
DWG — Drawing
ELEV — Elevation (elevator)
E.M. — Expanded metal
EQUIP — Equipment
E. R. — Engine room
EVAP — Evaporation
EXH — Exhaust
EXP — Expanded
EXT — Extension
F.D.-Blower — Forced draft blower
FDK — Forecastle deck
F.E. — Forward end (front or bow)
F.K. — Flat keel
FLG — Flange
FLGD — Flanged
F.O. — Fuel oil
FOCS'LE — Forecastle
F.B. — Flat bar
F. & A. — Fore and Aft
FOR'D — Forward
FORD — Forward
FWD — Forward
FDN — Foundation
F.P. — Forepeak or forward perpendicular
F.P. — Flanged plate
FR — Frame
F.W. — Fresh water
GALV — Galvanized

GEN — Generator
GIR — Girder
GRD — Grind
HLS — Holes
H.R. — Half round
I — I beam
IB — Inboard
I.D. — Inside diameter
INBD — Inboard
INS — Insulation
INV — Inverted
KP — Kingpost
L — Angle, locker, length or longitudinal
L.B.P. — Length between perpendiculars
LBS or # — Pounds
L.O.A. — Length over all
L. or LON — Longitudinal
L.P. — Low pressure
LUB OIL — Lubricating oil
L.W.L. — Load water line
MAT — Material
MAX — Maximum
MFG — Manufacturing
M.H. — Manhole
MIN — Minimum
MISC — Miscellaneous
M.P. — Mooring pipe
NO — CSK — No countersink
N or # — Number
OB — Outboard
O.C. — Open chock
O.D. — Outside diameter
OPP — Opposite side
OPP — Opposite hand
O.S. — Other side
O.S.U. — Other side up
O.T. — Oiltight
OTBD — Outboard
O.T.H. — Oiltight hatch
P. & S. — Port and Starboard
P. — Port
P.C. — Pitch circle
PDK — Poop deck
PL, PLT or ℄ — Plate
PM — Pitch mark, check mark, or spot
R. or RAD — Radius
R.C. — Roller chock
REQ — Required
R.H. — Right hand
RIV — Rivet
R.O.T.M.H. — Raised Oiltight Manhole
S.C. DR. — Screen door
S.N.W.T. — Steel non-watertight
S.P. — Shell plate
SQ — Square
S.R. — Stateroom
STD — Standard
STBD. or S — Starboard
STIFF — Stiffener
SYS — System
T — T bar
T.C. — Towing chock
TEMP — Template
THD — Thread
THK — Thick
THRU — Through
T.S. — Tool steel, tensile strength, this side
T.S.U. — This side up
T.T. — Tank top
U — Up
UDK — Upper deck
V — Vent
VENT — Ventilation
VERT — Vertical
V.K. — Vertical Keel
V.L. — Vertical ladder
VOL — Volume
W — Weld
W.C. — Water closet
W.L. — Water line
W.M. — Wire mesh
W.R. — Wardrobe or washroom
W.T.M.H. — Watertight manhole
Z — Z bar

APPENDIX III
APPLIED ARITHMETIC

NUMERICAL CONVERSION (DECIMALS)

Decimal equivalents for fractional parts of an inch are encountered in all mechanical work. Circumferences are calculated or taken from already computed reference charts; in either case the results are always in inches and decimal parts of an inch. These decimals must be converted into fractions accurately in order to lay out the work correctly.

The conversion of a decimal to a fraction is the reverse of the conversion of a fraction to a decimal. For clarity of explanation the latter is presented first.

How to Change a Fraction to a Decimal

Problem: Change 9/64 to a decimal.

Solution: Divide the numerator by the denominator as follows:

> Note: The numerator is the part of the fraction above the horizontal line. The denominator is the part of the fraction below the horizontal line.

For example:

9 (Numerator)
64 (Denominator)

```
64 | 9.000000 | .140625
     64
     260
     256
       400
       384
        160
        128
         320
         320
```

Accordingly, .140625 is the decimal equivalent of 9/64.

How to Change a Decimal to a Fraction

PROBLEM: Change .140625 to a fraction the denominator of which is 64 (sixty-fourths).

Solution: Multiply the decimal by the denominator of the desired fraction (64).

$$\begin{array}{r l} .140625 & \\ 64 & \\ \hline 562500 & \\ 843750 & \\ \hline 9.000000 & \text{(Answer in number of 64ths.)} \end{array}$$

Accordingly, 9/64 is the fractional equivalent of .140625.

For convenience, any fractional part of an inch may be used; those shown on the mechanic's rule will be the most practical, as 1/64, 1/32, 1/16, $\frac{1}{8}$, etc. For those wishing to learn this convenient method, it is well to practice with fractions like 1/64 and 1/32. It is always easier to multiply the decimal by 64 and then reduce the fraction to a denomination that is considered close enough for the job than to reduce the decimal directly.

Thus .45312 x 64 = 28.999 sixty-fourths or 29/64ths. If multiplied by 32, .45312 x 32 = 14.4998 thirty-seconds, i.e., $14\frac{1}{2}$/32nds. If multiplied by 16, .45312 x 16 = 7.2499 sixteenths, i.e., $7\frac{1}{4}$/16ths. This is an illustration of the convenience of reducing to 64ths.

The same rule may be applied to the decimals of a foot by multiplying the decimal by 12.

Extracting Square Root

GENERAL INFORMATION

On many jobs it is necessary to find diagonal or slanting distances. In the majority of cases these distances may be readily measured with a folding rule, a steel tape, or a measuring stick. There are certain jobs that can not be measured in this way because of temporary obstructions or because the size of the job may be beyond the capacity of the measuring tool. For example, it may be necessary to determine whether a bulkhead is, or is not, squared with the position of the deck. Then, too, it may be necessary to know if certain vertical constructions are square with a horizontal member such as special staging or angular bracing. When it becomes necessary to take measurements and check jobs of this nature, the fundamental principles of square root may be employed. To understand these methods of measuring and checking thoroughly, it will be necessary to know how to extract the square root of a number.

Root of a Number

The root of a number is one of the equal factors which produce it, or it is the number used to start with.

Root Sign

The radical sign $\sqrt{\ }$ is used to indicate a root. A small figure placed over the radical sign indicates how many equal factors are to be found.

$\sqrt{3}$ or $\sqrt[2]{3}$ means to find the square root of 3. The square root of 183184 will have three figures or three divisions, 18′ 31′ 84; 21418384 will have four figures and four divisions, 21′ 41′ 83′ 84; and 9703225 will also have four figures and four divisions — 9′ 70′ 32′ 25, but three divisions have two figures each, and one division has only one figure. Try finding the square root of 203401, marking it off into periods.

```
         20′ 34′ 01.    | 451 Ans.
     4   16
          434
  85      425
            901
901         901
```

Solution:

1. Separate the number into periods of two figures each, beginning at the decimal point.
2. Find the largest root which when squared will be contained in the left-hand period. This root is 4; place the 4 in the quotient as the first figure of the complete root.
3. Subtract the greatest square (16) from the first period (20), and bring down the next period with the remainder (4) making 434 for a new dividend.
4. Double the root already found (4) for a trial divisor ($2 \times 4 = 8$), and divide the trial divisor (8) into the new dividend (434) excluding the right-hand figure; this process ($43 \div 8$) gives 5. Place 5 after the 8 in the trial divisor, making 85; also place the 5 after the 4 in the quotient, making the quotient 45. Multiply the divisor (85) by the new root in the quotient ($5 \times 85 = 425$), and subtract this product from the new dividend ($434 - 425 = 9$). Then bring down the new period, which is 01, to make 901. Proceed as before for the next new root. Try finding the square roots of the following:—

1. 784	5. 874225
2. 8464	6. 1799007056
3. 49729	7. 48841
4. 255036	8. 105976

Find Square Root of Decimals

To find the square root of a decimal begin at the decimal point and mark off periods to the right.

	.29′16	.54 Ans.
5	25	
	416	
104	416	

To find the square root of a whole number and a decimal, begin at the decimal point and mark off two-figure periods to the right; then mark off two-figure periods to the left.

	5′80.81′	24.1 Ans.
2	4	
	180	
44	176	
	481	
481	481	

Try finding the square roots of the following:

1. .625	4. 7832.25	7. 3124.81
2. .96721	5. 98.4064	8. .616225
3. .40401	6. 3.8416	9. 4.9284

Figure 602 shows two lines at right angles to each other. The length of one side is 4 in. The length of the other side is 3 in. The distance A may be found by using the principles of square root. The principles of square root are shown in Fig. 603.

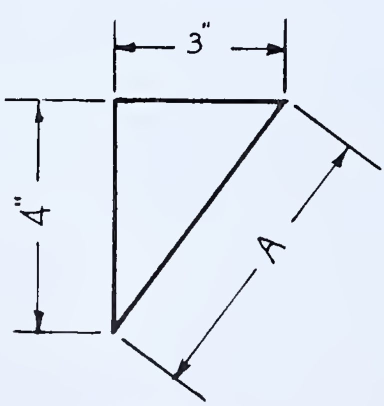


Fig. 602

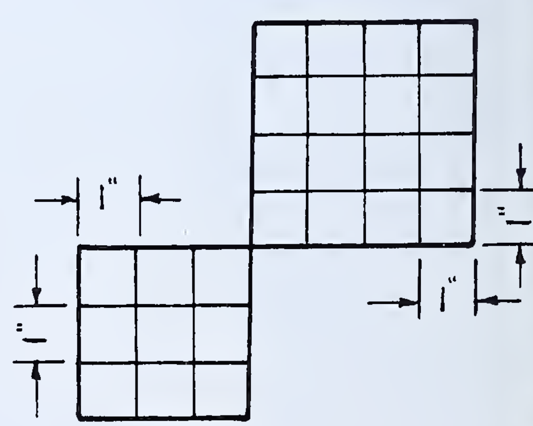


Fig. 603

A square is built around, or formed around, the first side, 4 in. each way. This is called "squaring" 4 in. The squares are 1 in. each way. A square is built the same way on the 3-inch side. The 3-inch side is now "squared."

Examine the number of squares. 16 squares will be formed in the large square; 9 squares will be formed in the small square. Add the squares together. There are 25 in all. Examine Fig. 604.

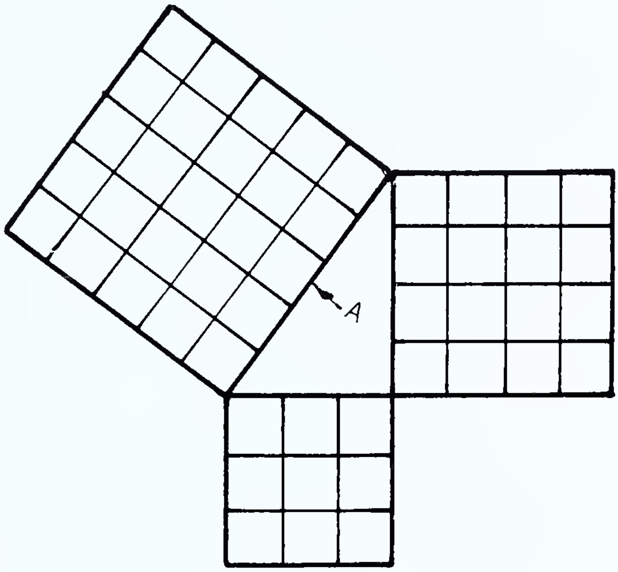


FIG. 604

Add the squares in the two small squares making 25 in all. Count the squares in the largest square. There are 25 squares of the same size in the smaller squares. The length of side A must be the square root of 25 which is 5, for 5 x 5 = 25.

From the example the standard rule for finding the length of the third side of a right-angled triangle follows:

RULE:

1. Square each side of the triangle.
2. Add the squares together.
3. Extract, or find, the square root of the sum of the squares.
   The answer will be the length of the third side.

PROBLEM: Find the distance from corner to corner (diagonal) of the rectangular plate shown in Fig. 605.

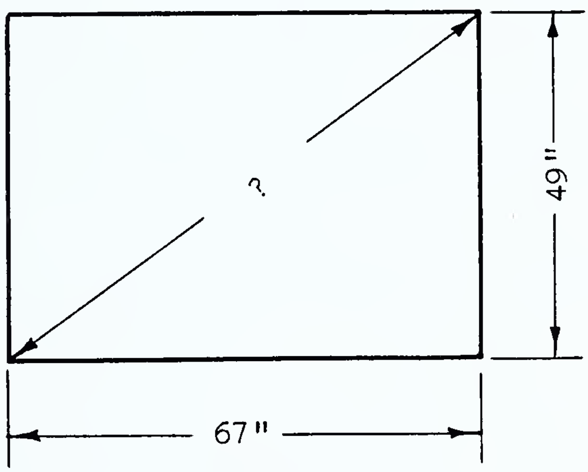


FIG 605

APPENDIX IV

CAPACITIES OF CYLINDRICAL TANKS

The capacity of a cylindrical tank can be found by multiplying the area enclosed by the circumference of the cylinder by the height or length of the tank.

Let V = Capacity (or volume)
d = Diameter
c = Circumference
H = Height (or length)
S = Area of Cylindrical surface

Then $S = \pi r^2 = 3.1416 \times r^2$

$V = \pi r^2 h$

Problem: Find the volume (capacity) of a cylindrical tank 5′ inside diameter and 15′ long.

Solution: Area of cylindrical surface = 2827.4″

Height of cylinder = 180″

$V = 2827.4 \times 180'' = 508932$ cubic inches or

$508932 \div 1728 = 294.52$ cubic feet approximately.

In solving this problem refer to the table of Circumferences and Areas of Circles, beginning on the following page, and to Appendix VII.

When the diameter of the required circle cannot be found in the table proceed as follows:

Find the area of a circle whose diameter is 54-5/16 inches.

Solution:

54-5/16″ = 54.3125 (See Appendix VI)

$A = \pi r^2$

$r = 54.3125 \div 2 = 27.15625''$

$27.15625^2 = 736.86$ square inches

$A = 736.86 \times 3.1416 = 2314.91$ square inches.

Refer to the table of Circumferences and Areas of Circles and it will be seen that the area of a 54-5/16″ circle falls between the areas of 54¼″ circle and a 54⅜″ circle.

Useful Tables

Circle, square, sphere, and weight.

To find circumference:
Multiply diameter by: 3.1416
or divide diameter by: 0.3183

To find diameter:
Multiply circumference by: 0.3183
or divide circumference by: 3.1416

To find radius:
Multiply circumference by: 0.15915
or divide circumference by: 6.28318

To find side of inscribed square:
Multiply diameter by: 0.7071
or multiply circumference by: 0.2251
or divide circumference by: 4.4428

To find side of equal square:
Multiply diameter by: 0.8862
or divide diameter by: 1.1284
or multiply circumference by: 0.2821
or divide circumference by: 3.545

SQUARE:
A side multiplied by 1.4142 equals diameter of its circumscribing circle.
A side multiplied by 4.443 equals circumference of its circumscribing circle.
A side multiplied by 1.128 equals diameter of an equal circle.
A side multiplied by 3.547 equals circumference of an equal circle.

To find the area of a circle:
Multiply circumference by one quarter of the diameter,
or multiply the square of the diameter by 0.7854.

To find the surface of a sphere or globe:
Multiply the diameter by the circumference
or multiply the square of the diameter by 3.1416.

To find the cubic inches (volume) in a sphere or globe:
Multiply the cube of the diameter by 0.5236.

To find weight of brass, copper sheets, rods, and bars, find the number of cubic inches in the piece and multiply by the weight per cubic inch.

Aluminum — .0924, copper — .3184, brass — .2960, steel — .2816. (Figures are weights per cu. in.)

CIRCUMFERENCES AND AREAS OF CIRCLES

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA.
1/64	.04909	.00019	3/4	2.3562	.44179	2. 1/16	6.4795	3.3410
1/32	.09818	.00077	25/32	2.4544	.47937	1/8	6.6759	3.5466
3/64	.14726	.00173	13/16	2.5525	.51849	3/16	6.8722	3.7583
1/16	.19635	.00307	27/32	2.6507	.55914	1/4	7.0686	3.9761
3/32	.29452	.00690	7/8	2.7489	.60132	5/16	7.2649	4.2000
1/8	.39270	.01227	29/32	2.8471	.64504	3/8	7.4613	4.4301
5/32	.49087	.01917	15/16	2.9452	.69029	7/16	7.6576	4.6664
3/16	.58905	.02761	31/32	3.0434	.73708	1/2	7.8540	4.9087
7/32	.68722	.03758				9/16	8.0503	5.1572
			1.	3.1416	.7854	5/8	8.2467	5.4119
1/4	.78540	.04909	1/16	3.3379	.8866	11/16	8.4430	5.6727
9/32	.88357	.06213	1/8	3.5343	.9940	3/4	8.6394	5.9396
5/16	.98175	.07670	3/16	3.7306	1.1075	13/16	8.8357	6.2126
11/32	1.0799	.09281	1/4	3.9270	1.2272	7/8	9.0321	6.4918
3/8	1.1781	.11045	5/16	4.1233	1.3530	15/16	9.2284	6.7771
13/32	1.2763	.12962	3/8	4.3197	1.4849			
7/16	1.3744	.15033	7/16	4.5160	1.6230	3.	9.4248	7.0686
15/32	1.4726	.17257	1/2	4.7124	1.7671	1/16	9.6211	7.3662
			9/16	4.9087	1.9175	1/8	9.8175	7.6699
1/2	1.5708	.19635	5/8	5.1051	2.0739	3/16	10.014	7.9798
17/32	1.6690	.22166	11/16	5.3014	2.2365	1/4	10.210	8.2958
9/16	1.7671	.24850	3/4	5.4978	2.4053	5/16	10.407	8.6179
19/32	1.8653	.27688	13/16	5.6941	2.5802	3/8	10.603	8.9462
5/8	1.9635	.30680	7/8	5.8905	2.7612	7/16	10.799	9.2806
21/32	2.0617	.33824	15/16	6.0868	2.9483	1/2	10.996	9.6211
11/16	2.1598	.37122				9/16	11.192	9.9678
23/32	2.2580	.40574	2.	6.2832	3.1416	5/8	11.388	10.321

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
3. 11/16	11.585	10.680	5. 3/8	16.886	22.691	8.	25.133	50.265
3/4	11.781	11.045	7/16	17.082	23.221	1/8	25.525	51.849
13/16	11.977	11.416	1/2	17.279	23.758	1/4	25.918	53.456
7/8	12.174	11.793	9/16	17.475	24.301	3/8	26.311	55.088
15/16	12.370	12.177	5/8	17.671	24.850	1/2	26.704	56.745
			11/16	17.868	25.406	5/8	27.096	58.426
4.	12.566	12.566	3/4	18.064	25.967	3/4	27.489	60.132
1/16	12.763	12.962	13/16	18.261	26.535	7/8	27.882	61.862
1/8	12.959	13.364	7/8	18.457	27.109			
3/16	13.155	13.772	15/16	18.653	27.688	9.	28.274	63.617
1/4	13.352	14.186				1/8	28.667	65.397
5/16	13.548	14.607	6.	18.850	28.274	1/4	29.060	67.201
3/8	13.744	15.033	1/8	19.242	29.465	3/8	29.452	69.029
7/16	13.941	15.466	1/4	19.635	30.680	1/2	29.845	70.882
1/2	14.137	15.904	3/8	20.028	31.919	5/8	30.238	72.760
9/16	14.334	16.349	1/2	20.420	33.183	3/4	30.631	74.662
5/8	14.530	16.800	5/8	20.813	34.472	7/8	31.023	76.589
11/16	14.726	17.257	3/4	21.206	35.785			
3/4	14.923	17.728	7/8	21.598	37.122	10.	31.416	78.540
13/16	15.119	18.190				1/8	31.809	80.516
7/8	15.315	18.665	7.	21.991	38.485	1/4	32.201	82.516
15/16	15.512	19.147	1/8	22.384	39.871	3/8	32.594	84.541
			1/4	22.776	41.282	1/2	32.987	86.590
5.	15.708	19.635	3/8	23.169	42.718	5/8	33.379	88.664
1/16	15.904	20.129	1/2	23.562	44.179	3/4	33.772	90.763
1/8	16.101	20.629	5/8	23.955	45.664	7/8	34.165	92.886
3/16	16.297	21.135	3/4	24.347	47.173			
1/4	16.493	21.648	7/8	24.740	48.707	11.	34.558	95.033
5/16	16.690	22.166				1/8	34.950	97.205

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
11. 1/4	35.343	99.402	14. 1/2	45.553	165.13	17. 3/4	55.763	247.45
3/8	35.736	101.62	5/8	45.946	167.99	7/8	56.156	250.95
1/2	36.128	103.87	3/4	46.338	170.87			
5/8	36.521	106.14	7/8	46.731	173.78	18.	56.549	254.47
3/4	36.914	108.43				1/8	56.941	258.02
7/8	37.306	110.75	15.	47.124	176.71	1/4	57.334	261.59
			1/8	47.517	179.67	3/8	57.727	265.18
12.	37.699	113.10	1/4	47.909	182.65	1/2	58.119	268.80
1/8	38.092	115.47	3/8	48.302	185.66	5/8	58.512	272.45
1/4	38.485	117.86	1/2	48.695	188.69	3/4	58.905	276.12
3/8	38.877	120.28	5/8	49.087	191.75	7/8	59.298	279.81
1/2	39.270	122.72	3/4	49.480	194.83			
5/8	39.663	125.19	7/8	49.873	197.93	19.	59.690	283.53
3/4	40.055	127.68				1/8	60.083	287.27
7/8	40.448	130.19	16.	50.265	201.06	1/4	60.476	291.04
			1/8	50.658	204.22	3/8	60.868	294.83
13.	40.841	132.73	1/4	51.051	207.39	1/2	61.261	298.65
1/8	41.233	135.30	3/8	51.444	210.60	5/8	61.654	302.49
1/4	41.626	137.89	1/2	51.836	213.82	3/4	62.046	306.35
3/8	42.019	140.50	5/8	52.229	217.08	7/8	62.439	310.24
1/2	42.412	143.14	3/4	52.622	220.35			
5/8	42.804	145.80	7/8	53.014	223.65	20.	62.832	314.16
3/4	43.197	148.49				1/8	63.225	318.10
7/8	43.590	151.20	17.	53.407	226.98	1/4	63.617	322.06
			1/8	53.800	230.33	3/8	64.010	326.05
14.	43.982	153.94	1/4	54.192	233.71	1/2	64.403	330.06
1/8	44.375	156.70	3/8	54.585	237.10	5/8	64.795	334.10
1/4	44.768	159.48	1/2	54.978	240.53	3/4	65.188	338.16
3/8	45.160	162.30	5/8	55.371	243.98	7/8	65.581	342.25

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
21.	65.973	346.36	24. 1/4	76.184	461.86	27. 1/2	86.394	593.96
1/8	66.366	350.50	3/8	76.576	466.64	5/8	86.786	599.37
1/4	66.759	354.66	1/2	76.969	471.44	3/4	87.179	604.81
3/8	67.152	358.84	5/8	77.362	476.26	7/8	87.572	610.27
1/2	67.544	363.05	3/4	77.754	481.11			
5/8	67.937	367.28	7/8	78.147	485.98	28.	87.965	615.75
3/4	68.330	371.54				1/8	88.357	621,26
7/8	68.722	375.83	25.	78.540	490.87	1/4	88.750	626.80
			1/8	78.933	495.79	3/8	89.143	632.36
22.	69.115	380.13	1/4	79.325	500.74	1/2	89.535	637.94
1/8	69.508	384.46	3/8	79.718	505.71	5/8	89.928	643.55
1/4	69.900	388.82	1/2	80.111	510.71	3/4	90.321	649.18
3/8	70.293	393.20	5/8	80.503	515.72	7/8	90.713	654.84
1/2	70.686	397.61	3/4	80.896	520.77			
5/8	71.079	402.04	7/8	81.289	525.84	29.	91.106	660.52
3/4	71.471	406.49				1/8	91.499	666.23
7/8	71.864	410.97	26.	81.681	530.93	1/4	91.892	671.96
			1/8	82.074	536.05	3/8	92.284	677.71
23.	72.257	415.48	1/4	82.467	541.19	1/2	92.677	683.49
1/8	72.649	420.00	3/8	82.860	546.35	5/8	93.070	689.30
1/4	73.042	424.56	1/2	83.252	551.55	3/4	93.462	695.13
3/8	73.435	429.13	5/8	83.645	556.76	7/8	93.855	700.98
1/2	73.827	433.74	3/4	84.038	562.00			
5/8	74.220	438.36	7/8	84.430	567.27	30.	94.248	706.86
3/4	74.613	443.01				1/8	94.640	712.76
7/8	75.006	447.69	27.	84.823	572.56	1/4	95.033	718.69
			1/8	85.216	577.87	3/8	95.426	724.64
24.	75.398	452.39	1/4	85.608	583.21	1/2	95.819	730.62
1/8	75.791	457.11	3/8	86.001	588.57	5/8	96.211	736.62

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
30. 3/4	96.604	742.64	34.	106.814	907.92	37. 1/4	117.024	1089.8
7/8	96.997	748.69	1/8	107.207	914.61	3/8	117.417	1097.1
			1/4	107.600	921.32	1/2	117.810	1104.5
31.	97.389	754.77	3/8	107.992	928.06	5/8	118.202	1111.8
1/8	97.782	760.87	1/2	108.385	934.82	3/4	118.596	1119.2
1/4	98.175	766.99	5/8	108.778	941.61	7/8	118.988	1126.7
3/8	98.567	773.14	3/4	109.170	948.42			
1/2	98.960	779.31	7/8	109.563	955.25	38.	119.381	1134.1
5/8	99.353	785.51				1/8	119.773	1141.6
3/4	99.746	791.73	35.	109.956	962.11	1/4	120.166	1149.1
7/8	100.138	797.98	1/8	110.348	969.00	3/8	120.559	1156.6
			1/4	110.741	975.91	1/2	120.951	1164.2
32.	100.531	804.25	3/8	111.134	982.84	5/8	121.344	1171.7
1/8	100.924	810.54	1/2	111.527	989.80	3/4	121.737	1179.3
1/4	101.316	816.86	5/8	111.919	996.78	7/8	122.129	1186.9
3/8	101.709	823.21	3/4	112.312	1003.8			
1/2	102.102	829.58	7/8	112.705	1010.8	39.	122.522	1194.6
5/8	102.494	835.97				1/8	122.915	1202.3
3/4	102.887	842.39	36.	113.097	1017.9	1/4	123.308	1210.6
7/8	103.280	848.83	1/8	113.490	1025.0	3/8	123.700	1217.7
			1/4	113.883	1032.1	1/2	124.093	1225.4
33.	103.673	855.30	3/8	114.275	1039.2	5/8	124.486	1233.2
1/8	104.065	861.79	1/2	114.668	1046.3	3/4	124.878	1241.0
1/4	104.458	868.31	5/8	115.061	1053.5	7/8	125.271	1248.8
3/8	104.851	874.85	3/4	115.454	1060.7			
1/2	105.243	881.41	7/8	115.846	1068.0	40.	125.664	1256.6
5/8	105.636	888.00				1/8	126.056	1264.5
3/4	106.029	894.62	37.	116.239	1075.2	1/4	126.449	1272.4
7/8	106.421	901.26	1/8	116.632	1082.5	3/8	126.842	1280.3

CIRCUMFERENCES AND AREAS OF CIRCLES –. CONTINUED

CIRUUM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
40. 1/2	127.235	1288.2	43. 3/4	137.445	1503.3	47.	147.655	1734.9
5/8	127.627	1296.2	7/8	137.837	1511.9	1/8	148.048	1744.2
3/4	128.020	1304.2				1/4	148.440	1753.5
7/8	128.413	1312.2	44.	138.230	1520.5	3/8	148.833	1762.7
			1/8	138.623	1529.2	1/2	149.226	1772.1
41.	128.805	1320.3	1/4	139.015	1537.9	5/8	149.618	1781.4
1/8	129.198	1328.3	3/8	139.408	1546.6	3/4	150.011	1790.8
1/4	129.591	1336.4	1/2	139.801	1555.3	7/8	150.404	1800.1
3/8	129.983	1344.5	5/8	140.194	1564.0			
1/2	130.376	1352.7	3/4	140.586	1572.8	48.	150.796	1809.6
5/8	130.769	1360.8	7/8	140.979	1581.6	1/8	151.189	1819.0
3/4	131.161	1369.0				1/4	151.582	1828.5
7/8	131.554	1377.2	45.	141.372	1590.4	3/8	151.975	1837.9
			1/8	141.764	1599.3	1/2	152.367	1847.5
42.	131.947	1385.4	1/4	142.157	1608.2	5/8	152.760	1857.0
1/8	132.340	1393.7	3/8	142.550	1617.0	3/4	153.153	1866.5
1/4	132.732	1402.0	1/2	142.942	1626.0	7/8	153.545	1876.1
3/8	133.125	1410.3	5/8	143.335	1634.9			
1/2	133.518	1418.6	3/4	143.728	1643.9	49.	153.938	1885.7
5/8	133.910	1427.0	7/8	144.121	1652.9	1/8	154.331	1895.4
3/4	134.303	1435.4				1/4	154.723	1905.0
7/8	134.696	1443.8	46.	144.513	1661.9	3/8	155.116	1914.7
			1/8	144.906	1670.9	1/2	155.509	1924.4
43.	135.088	1452.2	1/4	145.299	1680.0	5/8	155.902	1934.2
1/8	135.481	1460.7	3/8	145.691	1689.1	3/8	156.294	1943.9
1/4	135.874	1469.1	1/2	146.084	1698.2	7/8	156.687	1953.7
3/8	136.267	1477.6	5/8	165.477	1707.4			
1/2	136.659	1486.2	3/4	146.869	1716.5	50.	157.080	1963.5
5/8	137.052	1494.7	7/8	147.262	1725.7	1/8	157.472	1973.3

CIRCUMFERENCES AND AREAS OF CIRCLES --CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
50. 1/4	157.865	1983.2	53. 1/2	168.075	2248.0	56. 3/4	178.285	2529,4
3/8	158.258	1993.1	5/8	168.468	2258.5	7/8	178.678	2540.6
1/2	158.650	2003.0	3/4	168.861	2269.1			
5/8	159.043	2012.9	7/8	169.253	2279.6	57.	179.071	2551.8
3/4	159.436	2022.8				1/8	179.463	2563.0
7/8	159.829	2032.8	54.	169.646	2290.2	1/4	179.856	2574.2
			1/8	170.039	2300.8	3/8	180.249	2585.4
51.	160.221	2042.8	1/4	170.431	2311.5	1/2	180.642	2596.7
1/8	160.614	2052.8	3/8	170.824	2322.1	5/8	181.034	2608.0
1/4	161.007	2062.9	1/2	171.217	2332.8	3/4	181.427	2619.4
3/8	161.399	2073.0	5/8	171.609	2343.5	7/8	181.820	2630.7
1/2	161.792	2083.1	3/4	172.002	2354.3			
5/8	162.185	2093.2	7/8	172.395	2365.0	58.	182.212	2642.1
3/4	162.577	2103.3				1/8	182.605	2653.5
7/8	162.970	2113.5	55.	172.788	2375.8	1/4	182.998	2664.9
			1/8	173.180	2386.6	3/8	183.390	2676.4
52.	163.363	2123.7	1/4	173.573	2397.5	1/2	183.783	2687.8
1/8	163.756	2133.9	3/8	173.966	2408.3	5/8	184.176	2699.3
1/4	164.148	2144.2	1/2	174.358	2419.2	3/4	184.569	2710.9
3/8	164.541	2154.5	5/8	174.751	2430.1	7/8	184.961	2722.4
1/2	164.934	2164.8	3/4	175.144	2441.1			
5/8	165.326	2175.1	7/8	175.536	2452.0	59.	185.354	2734.0
3/4	165.719	2185.4				1/8	185.747	2745.6
7/8	166.112	2195.8	56.	175.929	2463.0	1/4	186.139	2757.2
			1/8	176.322	2474.0	3/8	186.532	2768.8
53.	166.504	2206.2	1/4	176.715	2485.0	1/2	186.925	2780.5
1/8	166.897	2216.6	3/8	177.107	2496.1	5/8	187.317	2792.2
1/4	167.290	2227.0	1/2	177.500	2507.2	3/4	187.710	2803.9
3/8	167.683	2237.5	5/8	177.893	2518.3	7/8	188.103	2815.7

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
60.	188.496	2827.4	1/4	198.706	3142.0	66. 1/2	208.916	3473.2
1/8	188.888	2839.2	3/8	199.098	3154.5	5/8	209.309	3486.3
1/4	189.281	2851.0	1/2	199.491	3166.9	3/4	209.701	3499.4
3/8	189.674	2862.9	5/8	199.884	3179.4	7/8	210.094	3512.5
1/2	190.066	2874.8	3/4	200.277	3191.9			
5/8	190.459	2886.6	7/8	200.669	3204.4	67.	210.487	3525.7
3/4	190.852	2898.6				1/8	210.879	3538.8
7/8	191.244	2910.5	64.	201.062	3217.0	1/4	211.272	3552.0
			1/8	201.455	3229.6	3/8	211.665	3565.2
61.	191.637	2922.5	1/4	201.847	3242.2	1/2	212.058	3578.5
1/8	192.030	2934.5	3/8	202.240	3254.8	5/8	212.450	3591.7
1/4	192.423	2946.5	1/2	202.633	3267.5	3/4	212.843	3605.0
3/8	192.815	2958.5	5/8	203.025	3280.1	7/8	213.236	3618.3
1/2	193.208	2970.6	3/4	203.418	3292.8			
5/8	193.601	2982.7	7/8	203.811	3305.6	68.	213.628	3631.7
3/4	193.993	2994.8				1/8	214.021	3645.0
7/8	194.386	3006.9	65.	204.204	3318.3	1/4	214.414	3658.4
			1/8	204.596	3331.1	3/8	214.806	3671.8
62.	194.779	3019.1	1/4	204.989	3343.9	1/2	215.199	3685.3
1/8	195.171	3031.3	3/8	205.382	3356.7	5/8	215.592	3698.7
1/4	195.564	3043.5	1/2	205.774	3369.6	3/4	215.984	3712.2
3/8	195.957	3055.7	5/8	206.167	3382.4	7/8	216.377	3725.7
1/2	196.350	3068.0	3/4	206.560	3395.3			
5/8	196.742	3080.3	7/8	206.952	3408,2	69.	216.770	3739.3
3/4	197.135	3092.6				1/8	217.163	3752.8
7/8	197.528	3104.9	66.	207.345	3421.2	1/4	217.555	3766.4
			1/8	207.738	3434.2	3/8	217.948	3780.0
63.	197.920	3117.2	1/4	208.131	3447.2	1/2	218.341	3793.7
1/8	198.313	3129.6	3/8	208.523	3460.2	5/8	218.733	3807.3

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
69. 3/4	219.126	3821.0	73.	229.336	4185.4	76. 1/4	239.546	4566.4
7/8	219.519	3834.7	1/8	229.729	4199.7	3/8	239.939	4581.3
			1/4	230.122	4214.1	1/2	240.332	4596.3
70.	219.911	3848.5	3/8	230.514	4228.5	5/8	240.725	4611.4
1/8	220.304	3862.2	1/2	230.907	4242.9	3/4	241.117	4626.4
1/4	220.697	3876.0	5/8	231.300	4257.4	7/8	241.510	4641.5
3/8	221.090	3889.8	3/4	231.692	4271.8			
1/2	221.482	3903.6	7/8	232.085	4286.3	77.	241.903	4656.6
5/8	221.875	3917.5				1/8	242.295	4671.8
3/4	222.268	3931.4	74.	232.478	4300.8	1/4	242.688	4686.9
7/8	222.660	3945.3	1/8	232.871	4315.4	3/8	243.081	4702.1
			1/4	233.263	4329.9	1/2	243.473	4717.3
71.	223.053	3959.2	3/8	233.656	4344.5	5/8	243.866	4732.5
1/8	223.446	3973.1	1/2	234.049	4359.2	3/4	244.259	4747.8
1/4	223.838	3987.1	5/8	234.441	4373.8	7/8	244.652	4763.1
3/8	224.231	4001.1	3/4	234.834	4388.5			
1/2	224.624	4015.2	7/8	335.227	4403.1	78.	245.044	4778.4
5/8	225.017	4029.2				1/8	245.437	4793.7
3/4	225.409	4043.3	75.	235.619	4417.9	1/4	245.830	4809.0
7/8	225.802	4057.4	1/8	236.012	4432.6	3/8	246.222	4824.4
			1/4	236.405	4447.4	1/2	246.615	4839.8
72.	226.195	4071.5	3/8	236.798	4462.2	5/8	247.008	4855.2
1/8	226.587	4085.7	1/2	237.190	4477.0	3/4	247.400	4870.7
1/4	226.980	4099.8	5/8	237.583	4491.8	7/8	247.793	4886.2
3/8	227.373	4114.0	3/4	237.976	4506.7			
1/2	227.765	4128.2	7/8	238.368	4521.5	79.	248.186	4901.7
5/8	228.158	4142.5				1/8	248.579	4817.2
3/4	228.551	4156.8	76.	238.761	4536.5	1/4	248.971	4932.7
7/8	228.944	4171.1	1/8	239.154	4551.4	3/8	249.364	4948.3

CIRCUMFERENCES AND AREAS OF CIRCLES -- CONTINUED

DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA	DIAM.	CIRCUM.	AREA
79. 1/2	249.757	4963.9	82. 7/8	260.359	5394.3	86. 1/8	270.570	5825.7
5/8	250.149	4979.5				1/4	270.962	5842.6
3/4	250.542	4995.2	83.	260.752	5410.6	3/8	271.355	5859.6
7/8	250.935	5010.9	1/8	261.145	5426.9	1/2	271.748	5776.5
			1/4	261.538	5443.3	5/8	272.140	5893.5
80.	251.327	5026.5	3/8	261.930	5459.6	3/4	272.533	5910.6
1/8	251.720	5042.3	1/2	262.323	5476.0	7/8	272.926	5927.6
1/4	252.113	5058.0	5/8	262.716	5492.4			
3/8	252.506	5073.8	3/4	263.108	5508.8	87.	273.319	5944.7
1/2	252.898	5089.6	7/8	263.501	5525.3	1/8	273.711	5961.8
5/8	253.291	5105.4				1/4	274.104	5978.9
3/4	253.684	5121.2	84.	263.894	5541.8	3/8	274.497	5996.0
7/8	254.076	5137.1	1/8	264.286	5558.3	1/2	274.889	6013.2
			1/4	264.679	5574.8	5/8	275.282	6030.4
81.	254.469	5153.0	3/8	265.072	5591.4	3/4	275.675	6047.6
1/8	254.862	5168.9	1/2	265,465	5607.9	7/8	276.067	6064.9
1/4	255.254	5184.9	5/8	265.857	5624.5			
3/8	255.647	5200.8	3/4	266.250	5641.2	88.	276.460	6082.1
1/2	256.040	5216.8	7/8	266.643	5657.8	1/8	276.853	6099.4
5/8	256.433	5232.8				1/4	277.246	6116.7
3/4	256.825	5248.9	85.	267.035	5674.5	3/8	277.638	6134.1
7/8	257.218	5264.9	1/8	267.428	5691.2	1/2	278.031	6151.4
			1/4	267.821	5707.9	5/8	278.424	6168.8
82.	257.611	5281.0	3/8	268.213	5724.7	3/4	278.816	6186.2
1/8	258.003	5297.1	1/2	268.606	5741.5	7/8	279.209	6203.7
1/4	258.396	5313.3	5/8	268.999	5758.3			
3/8	258.789	5329.4	3/4	269.392	5775.1	89.	279.602	6221.1
1/2	259.181	5345.6	7/8	269.784	5791.9	1/8	279.994	6238.6
5/8	259.574	5361.8				1/4	280.387	6256.1
3/4	259.967	5378.1	86.	270.177	5808.8	3/8	280.780	6273.7

CIRCUMFERENCES AND AREAS OF CIRCLES — CONCLUDED

DIAM.	CIRCUM.	AREA
89. 1/2	281.173	6291.2
5/8	281.565	6308.8
3/4	281.958	6326.4
7/8	282.351	6344.1
90.	282.743	6361.7
1/8	283.136	6379.4
1/4	283.529	6397.1
3/8	283.921	6414.9
1/2	284.314	6432.6
5/8	284.707	6450.4
3/4	285.100	6468.2
7/8	285.492	6486.0
91.	285.885	6503.9
1/8	286.278	6521.8
1/4	286.670	6539.7
3/8	287.063	6557.6
1/2	287.456	6575.5
5/8	287.848	6593.5
3/4	288.241	6611.5
7/8	288.634	6629.6
92.	289.027	6647.6
1/8	289.419	6665.7
1/4	289.812	6683.8
3/8	290.205	6701.9
1/2	290.597	6720.1
5/8	290.990	6738.2
3/4	291.383	6756.4
7/8	291.775	6774.7

DIAM.	CIRCUM.	AREA
93.	292.168	6792.9
1/8	292.561	6811.2
1/4	292.954	6829.5
3/8	293.346	6847.8
1/2	293.739	6866.1
5/8	294.132	6884.5
3/4	294.524	6902.9
7/8	294.917	6921.3
94.	295.310	6939.8
1/8	295.702	6958.2
1/4	296.095	6976.7
3/8	296.488	6995.3
1/2	296.881	7013.8
5/8	297.273	7032.4
3/4	297.666	7051.0
7/8	298.059	7069.6
95.	298.451	7088.2
1/8	298.844	7106.9
1/4	299.237	7125.6
3/8	299.629	7144.3
1/2	300.022	7163.0
5/8	300.415	7181.8
3/4	300.807	7200.6
7/8	301.200	7219.4
96.	301.593	7238.2
1/8	301.986	7257.1
1/4	302.378	7276.0
3/8	302.771	7294.9

DIAM.	CIRCUM.	AREA
96. 1/2	303.164	7313.8
5/8	303.556	7332.8
3/4	303.949	7351.8
7/8	304.342	7370.8
97.	304.734	7389.8
1/8	305.127	7408.9
1/4	305.520	7428.0
3/8	305.913	7447.1
1/2	306.305	7466.2
5/8	306.698	7485.3
3/4	307.091	7504.5
7/8	307.483	7523.7
98.	307.876	7543.0
1/8	308.269	7562.2
1/4	308.661	7581.5
3/8	309.054	7600.8
1/2	309.447	7620.1
5/8	309.840	7639.5
3/4	310.232	7658.9
7/8	310.625	7678.3
99.	311.018	7697.7
1/8	311.410	7717.1
1/4	311.803	7736.6
3/8	312.196	7756.1
1/2	312.588	7775.6
5/8	312.981	7795.2
3/4	313.374	7814.8
7/8	313.767	7834.4
100.	314.159	7854.0

APPENDIX V

DIMENSIONS OF STANDARD BOILER TUBES

DIMENSIONS AND AREAS OF STANDARD BOILER TUBES

DIAMETER		THICKNESS		CIRCUMFERENCE		TRANSVERSE AREAS			LENGTH OF TUBE PER SQUARE FOOT		NOMINAL WEIGHT PER FOOT POUNDS
O.D.	I.D.	INS.	NEAREST B. W. G.	EXTERNAL	INTERNAL	EXTERNAL	INTERNAL	METAL	EX. SURF.	IN. SURF.	
1	.810	.095	13	3.142	2.545	.7854	.5153	.2701	3.819	4.715	.90
1¼	1.060	.095	13	3.927	3.330	1.2272	.8825	.3447	3.056	3.603	1.15
1½	1.310	.095	13	4.712	4.115	1.7671	1.3478	.4193	2.547	2.916	1.40
1¾	1.560	.095	13	5.498	4.901	2.4053	1.9113	.4940	2.183	2.448	1.67
2	1.810	.095	13	6.283	5.686	3.1416	2.5730	.5686	1.909	2.110	1.93
2¼	2.060	.095	13	7.069	6.472	3.9761	3.3329	.6432	1.698	1.854	2.18
2½	2.282	.109	12	7.854	7.169	4.9087	4.0899	.8188	1.528	1.674	2.78
2¾	2.532	.109	12	8.639	7.954	5.9396	5.0349	.9047	1.389	1.508	3.07
3	2.782	.109	12	9.425	8.740	7.0686	6.0787	.9899	1.273	1.373	3.36
3¼"	3.010	.120	11	10.210	9.456	8.2958	7.1157	1.1801	1.175	1.269	4.01
3½	3.260	.120	11	10.996	10.242	9.6211	8.3469	1.274	1.091	1.171	4.33
3¾	3.510	.120	11	11.781	11.027	11.045	9.6762	1.369	1.018	1.088	4.65
4	3.732	.134	10	12.566	11.724	12.566	10.939	1.627	.955	1.024	5.53
4½	4.232	.134	10	14.137	13.295	15.904	14.066	1.838	.849	.902	6.24
5	4.704	.148	9	15.708	14.778	19.635	17.379	2.256	.764	.812	7.66
6	5.670	.165	8	18.850	17.813	28.274	25.249	3.025	.637	.673	10.28
7	6.670	.165	8	21.991	20.954	38.485	34.941	3.544	.546	.573	12.04
8	7.670	.165	8	25.133	24.096	50.265	46.204	4.061	.477	.498	13.80
9	8.640	.180	7	28.274	27.143	63.617	58.629	4.988	.424	.442	16.95
10	9.594	.203	6	31.416	30.140	78.540	72.291	6.249	.382	.398	21.24
11	10.560	.220	5	34.558	33.175	95.033	87.582	7.451	.347	.362	25.32
12	12.524	.229	....	37.699	36.260	113.10	104.63	8.47	.319	.330	28.78
13	12.524	.238	4	40.841	39.345	132.73	123.19	9.54	.294	.305	32.43
14	13.504	.248	....	43.982	42.424	153.94	143.22	10.72	.273	.283	36.42

DIMENSIONS AND AREAS OF STANDARD BOILER TUBES

DIAMETER		THICKNESS		CIRCUMFERENCE		TRANSVERSE AREAS			LENGTH OF TUBE PER SQUARE FOOT		NOMINAL WEIGHT PER FOOT POUNDS
O.D.	I.D.	INS.	NEAREST B.W.G.	EXTERNAL	INTERNAL	EXTERNAL	INTERNAL	METAL	EX. SURF.	IN. SURF.	
15	14.482	.259	3	47.124	45.496	176.71	164.72	11.99	.254	.264	40.77
16	15.460	.270	....	50.265	48.569	201.06	187.71	13.35	.239	.247	45.35
18	17.432	.284	2	56.549	54.764	254.47	238.66	15.81	.212	.219	53.00
20	19.376	.312	....	62.832	60.872	314.16	294.86	19.30	.190	.197	65.00
22	21.314	.343	0	69.115	66.960	380.13	356.80	23.33	.173	.179	78.00
24	23.25	.375	00	75.398	73.042	452.39	424.56	27.83	.159	.164	93.00
26	25.25	.375	00	81.681	79.325	530.93	500.74	30.19	.147	.151	101.00
28	27.25	.375	00	87.965	85.608	615.75	583.21	32.54	.136	.140	109.00
30	29.25	.375	00	94.248	91.892	706.86	671.96	34.90	.127	.130	117.00

Boiler tubes are manufactured to dimensions which are much more uniform than are pipe dimensions. Boiler-tube headers have to be drilled to take various diameters of boiler tubing and the drilled holes must be of a size to fit the tubing according to the specifications given on the blueprint. The blueprint may specify an easy fit or a tight fit.

The accompanying table contains all the necessary information that a boilermaker will have to use in connection with shop work. Any dimensions relevant to boiler tubes given on blueprints will be found in the table thus eliminating the necessity for measuring the outside or inside diameters.

It is essential for the boilermaker to know what size of boiler tube to use when the blueprint specifies a certain square inch internal or external heating area per foot of tube in length. This information is given in the table. Also the weight of a boiler tube of any length may be computed by referring to the table and multiplying the length of the tube by the weight per foot.

There are many other ways in which the table will be found useful in computing measurements when repair work is necessary in connection with Scotch boilers, stationary boilers, and other types of tubular boilers.

APPENDIX VI

DECIMAL EQUIVALENTS OF FRACTIONS OF ONE INCH

1/64	.015625
1/32	.03125
3/64	.046875
1/16	.0625
5/64	.078125
3/32	.09375
7/64	.109375
1/8	.1250
9/64	.140625
5/32	.15625
11/64	.171875
3/16	.1875
13/64	.203125
7/32	.21875
15/64	.234375
1/4	.2500
17/64	.265625
9/32	.28125
19/64	.296875
5/16	.3125
21/64	.328125
11/32	.34375
23/64	.359375
3/8	.3750
25/64	.390625
13/32	.40625
27/64	.421875
7/16	.4375
29/64	.453125
15/32	.46875
31/64	.484375
1/2	.5000
33/64	.515625
17/32	.53125
35/64	.546875
9/16	.5625
37/64	.578125
19/32	.59375
39/64	.609375
5/8	.6250
41/64	.640625
21/32	.65625
1	1.0000
43/64	.671875
11/16	.6875
45/64	.703125
23/32	.71875
47/64	.734375
3/4	.7500
49/64	.765625
25/32	.78125
51/64	.796875
13/16	.8125
53/64	.828125
27/32	.84375
55/64	.859375
7/8	.8750
57/64	.890625
29/32	.90625
59/64	.921875
15/16	.9375
61/64	.953125
31/32	.96875
63/64	.984375

APPENDIX VII
CAPACITIES OF CYLINDRICAL TANKS

DIAM. IN FEET	GALS	CU. FT.	DIAM. IN FEET	GALS.	CU. FT.	DIAM. IN FEET	GALS.	CU. FT.
1–1/2	13.2188	1.7671	11	710.894	95.033	23	3107.968	415.476
2	23.5007	3.1416	12	846.022	113.097	24	3384.096	452.389
2–1/2	36.7195	4.9087	13	992.902	132.732	25	3671.983	490.874
3	52.8767	7.0686	14	1151.533	153.938	26	3971.614	530.929
3–1/2	71.9706	9.6211	15	1321.917	176.715	27	4282.998	572.555
4	94.0030	12.5664	16	1504.044	201.062	28	4606.133	615.752
5	146.8796	19.6350	17	1697.924	226.980	29	4941.020	660.520
6	211.5059	28.2743	18	1903.555	254.469	30	5287.651	706.858
7	287.8833	38.4845	19	2120.939	283.529	31	5646.042	754.768
8	376.0111	50.2655	20	2350.066	314.159	32	6016.177	804.248
9	475.8892	63.6173	21	2590.954	346.361	33	6398.064	855.299
10	587.5170	78.5398	22	2843.585	380.133	34	6791.696	907.920

1 GALLON = 231 CU. IN. = 0.13368 CU. FT.; 1 CU. IN. = 0.004329 GALS.; 1 CU. FT. = 7.4805 GALS.

APPENDIX VIII

DIMENSIONS OF STEEL PIPE AND COUPLINGS

STANDARD STEEL PIPE					STANDARD COUPLINGS		
NOMINAL SIZE	OUTSIDE DIAMETER	INSIDE DIAMETER	THICKNESS	WEIGHT PER FT.	OUTSIDE DIAMETER	LENGTH	WEIGHT
1/8"	.405"	.269"	.068"	.244	.562"	7/8"	.03
1/2"	.840"	.622"	.109"	.850	1.024"	1-3/8"	.116
3/4"	1.050"	.842"	.113"	1.130	1.281"	1-5/8"	.209
1"	1.315"	1.049"	.133"	1.678	1.576"	1-7/8"	.343
2-1/2"	2.875"	2.469"	.203"	5.793	3.276"	2-7/8"	1.720
3"	3.500"	3.068"	.216"	7.575	3.948"	3-1/8"	2.498
3-1/2"	4.000"	3.548"	.226"	9.109	4.591"	3-5/8"	4.241
4"	4.500"	4.026"	.237"	10.790	5.091"	3-5/8"	4.741
X-H STEEL PIPE					LINE COUPLING		
1/2"	.840"	.546"	.147"	1.087	1.085"	1-7/8"	.28
3/4"	1.050"	.742"	.154"	1.473	1.316"	2-1/8"	.50
1"	1.315"	.957"	.179"	2.171	1.575"	2-3/8"	.56
2-1/2"	2.875"	2.323"	.276"	7.661	3.389"	4-1/8"	2.40
3"	3.500"	2.900"	.300"	10.252	4.014"	4-1/8"	3.46
3-1/2"	4.000"	3.364"	.318"	12.505	4.628"	4-5/8"	5.25
4"	4.500"	3.826"	.337"	14.983	5.216"	4-5/8"	6.80
XX-H STEEL PIPE							
1/2"	.840"	.252"	.294"	1.714			
3/4"	1.050"	.434"	.308"	2.440			
1"	1.315"	.599"	.358"	3.659			
2-1/2"	2.875"	1.771"	.552"	13.695			
3"	3.500"	2.300"	.600"	18.583			
3-1/2"	4.000	2.728"	.636"	22.850			
4"	4.500	3.152	.674"	27.541			

INDEX

A

Air casing, front:
- Asbestos packing strip for 314
- Drains and risers for 314
- Precautions when erecting an 313
- Purpose of an 313

Air casing, rear:
- Installation of an 322
- Precautions when installing an 321
- Purpose of an 322

Air heater:
- To install an 316, 317
- Purpose of an 316

B

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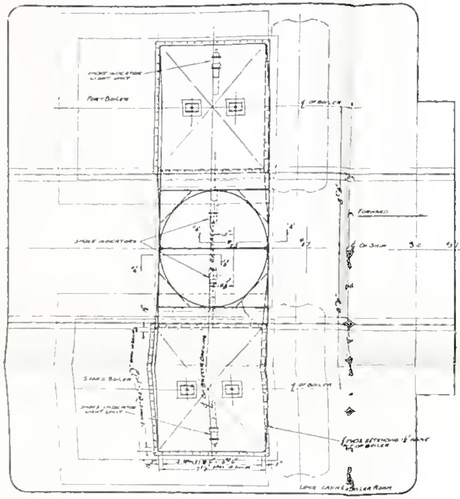

PLAN AT TOP OF UPTAKE

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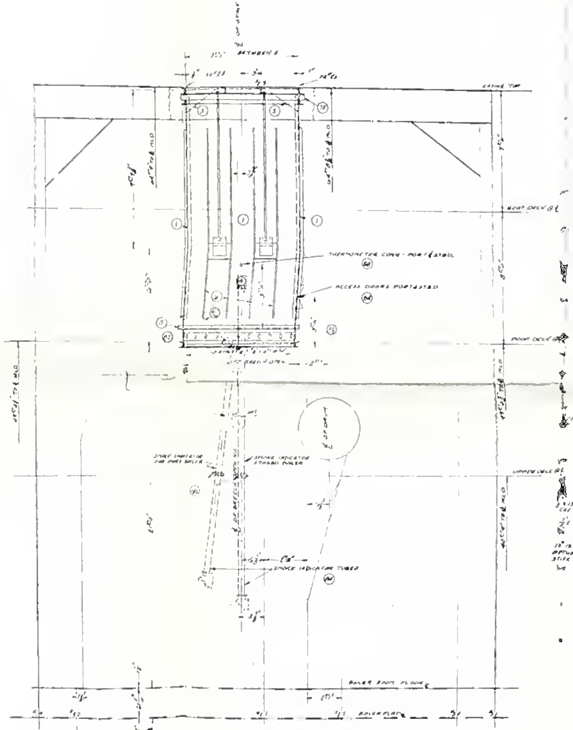
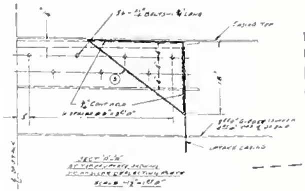


ELEVATION LOOKING TO PORT FROM STARBOARD SIDE OF SHIP



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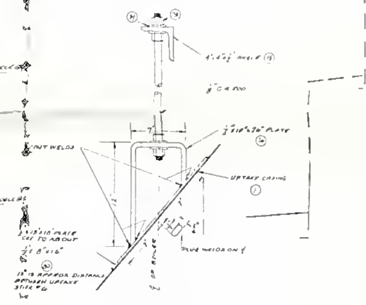
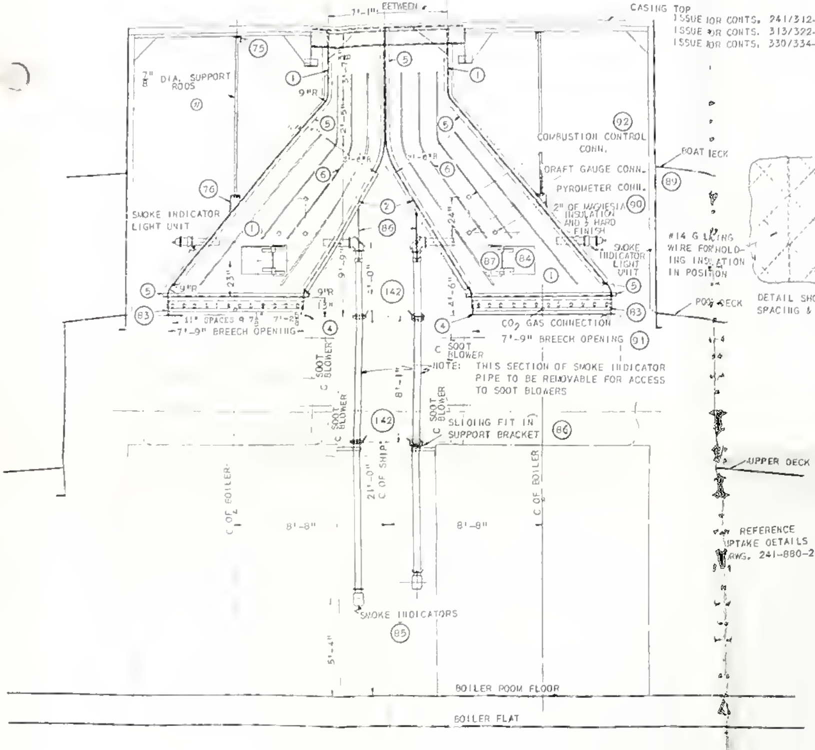


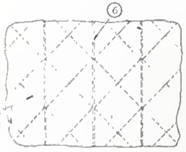
DETAIL OF UPTAKE SUPPORT

M



-SECTION AT FR. #30
-LOOKING AFT

BABCOCK & WILCOX MARINE BOILER UPTAKES



DETAIL SHOWING LACING WIRE, SPACING & STIFF. FOR INSULATION

N

NO. OF PIECES					PC. NO.	NAME OF PART	MAT'L	PATT NO.	REMARKS	DR. NO.
8	8	8	8	8	142	FLANGE FOR 4" PIPE 4½" PIPE TAP	F. S.	SCREWED	100# A.S.A. DRILLING FOR SMOKE INDICATOR PIPE	241-880-61
2	2	2	2	2	92	COMPLETE			COMBUSTION CONT CONN	241-880-2
2	2	2	2	2	91	COMPLETE			CO_2 GAS CONNECTION	"
2	2	2	2	2	90	COMPLETE			PYROMETER CONN.	"
2	2	2	2	2	89	COMPLETE			THERMOMETER CONN.	"
2	2	2	2	2	88	COMPLETE			THERMOMETER CONN.	241-880-2
2	2	2	2	2	87	10" X 22" X ¼"	STEEL	PLATE	REINFORCING PLATE	241-880-1
FT. 25	FT. 25	FT. 25	FT. 25	FT. 25	86	BRACKETS 2" X ¼"	STEEL	BAR	TO SUIT SMOKE IND. PIPES	"
FT. 48	FT. 48	FT. 48	FT. 48	FT. 48	85	4" STD. PIPE	SEAMLESS STEEL	CUT TO SUIT	SMOKE INDICATOR PIPES	"
2	2	2	2	2	84	20" X 17" X ¼"	STEEL	PLATE	ACCESS DOORS	"
4	4	4	4	4	83	10½" X 84" X 3/8"	STEEL	"	EXPANSION PIECE	"
4	4	4	4	4	82	10½" X 93" X 3/8"	STEEL	"	" "	"
56	56	56	56	56	81	½" SQ. HD. BOLTS	STEEL	1½" LONG HEX	NUTS - SUPPORT	"
4	4	4	4	4	80	18" X 18" X ½"	STEEL	PLATE	REINFORCING PLATE	"
16	16	16	16	16	79	7/8" DIA. WASHERS	STEEL	STANDARD	FOR PC. 77	"
16	16	16	16	16	78	7/8" HEX NUTS	STEEL	"	FOR PC. 77	"
4	4	4	4	4	77	7/8" DIA. RODS	STEEL	9 FT-0" LONG	EACH, THD. BOTH ENDS	"
4	4	4	4	4	76	10" X 26½ X ½"	STEEL	PLATE	SUPPORT BRACKETS	"
FT. 20	FT. 20	FT. 20	FT. 20	FT. 20	75	4" X 4" X ½"	STEEL	ANGLE	UPTAKE SUPPORTS	"
FT. 10	FT. 10	FT. 10	FT. 10	FT. 10	74	2" X ¼"	STEEL	FLAT BAR	STIFFENER-ACCESS DOOR	"
FT. 400	FT. 400	FT. 400	FT. 400	FT. 400	6	2" X 5/8"	STEEL	" "	UPTAKE STIFF. RIBS	"
FT. 220	FT. 220	FT. 220	FT. 220	FT. 220	5	2" X 2" X ¼"	STEEL	ANGLE	UPTAKE FRAME & INSULATION SUPPORT	"
FT. 80	FT. 80	FT. 80	FT. 80	FT. 80	4	2½" X 2½" X ¼"	STEEL	ANGLE	FLANGE AT BOILER	"
1	1	1	1	1	3	90" X 30" X 3/16"	STEEL	PLATE	DEFLECTOR PLATES	"
2	2	2	2	2	2	210" X 90" X ¼"	STEEL	PLATE	UPTAKE CASING INB'D	"
6	6	6	6	6	1	252" X 90" X ¼"	STEEL	PLATE	" " F. & A. & O. B.	241-880-1

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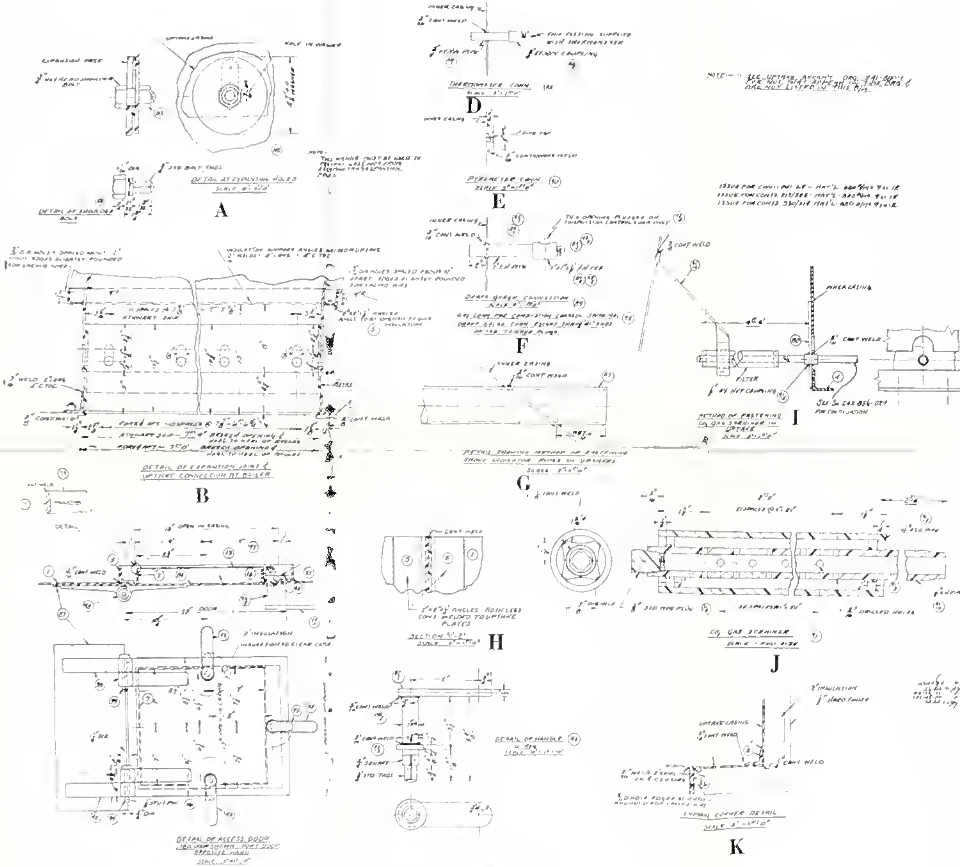
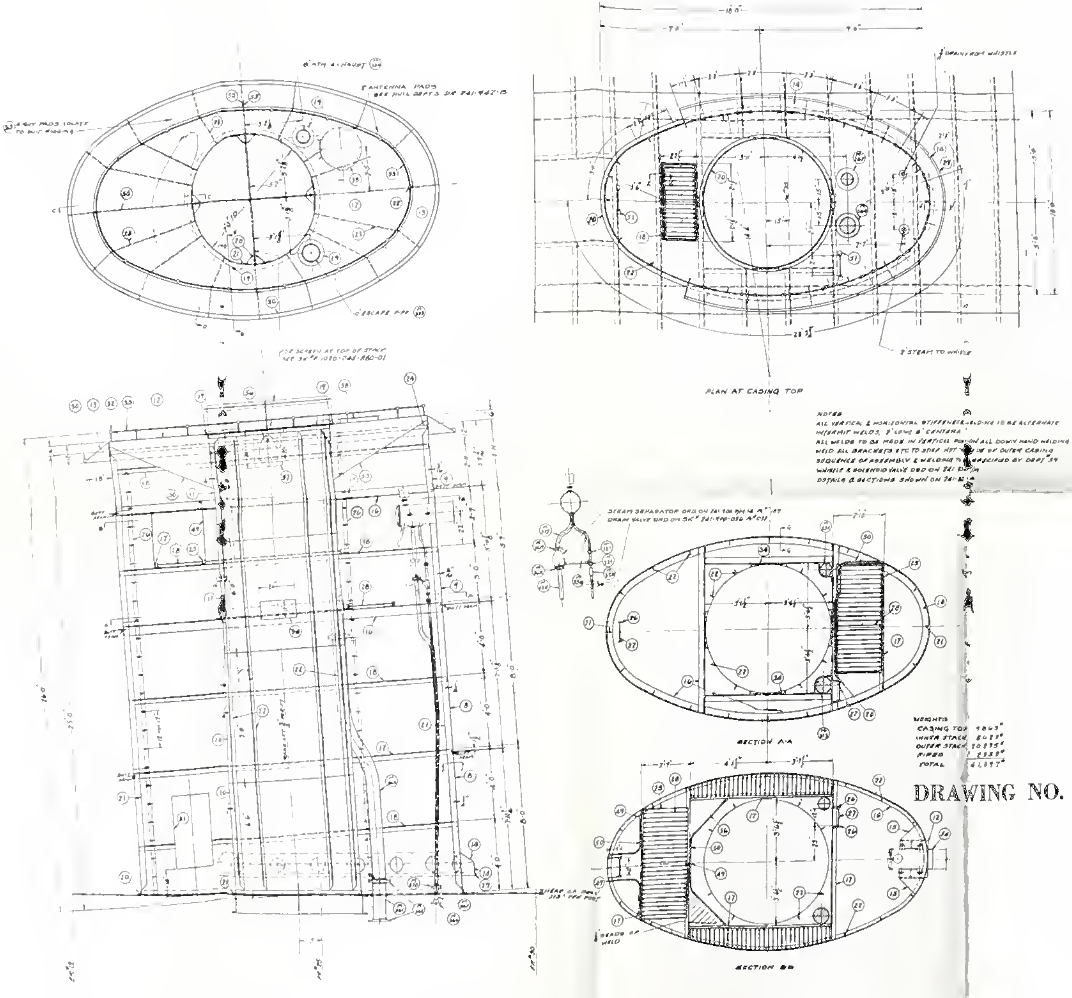


DRAWING NO. 241-880-2

1	1	1	1	1	25	FLT. 10" X 15" X 1/4" P.W.O.	STEEL		UPTAKE [illegible]	
92	92	92	92	92	[illegible]	1" STD. HEX. NUTS	STEEL		[illegible]	
92	92	92	92	92	[illegible]	WASHER	"	5/16" THICK	1-3/16" I.D. / 4-7/8" O.D.	
92	92	92	92	92	[illegible]	1" SHOULDER BOLT	"	CUT FROM 25'-0"	[illegible]	
4	4	4	4	4	[illegible]	1/8" SPLIT PIN	"	1-1/8" LONG		
4	4	4	4	4	[illegible]	HINGE PIN	"	CUT FROM [illegible]	[illegible]	
8	8	8	8	8	[illegible]	HINGE	F.S.	CIF [illegible]		
8	8	8	8	8	[illegible]	3/16" SPLIT PIN	STEEL	1-5/8" LONG		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1" STD. HEX. NUTS	"			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CATCH	F.S.	CIF [illegible]		
6	6	6	6	6	[illegible]	WASHER	STEEL	[illegible]	[illegible]	
6	6	6	6	4	-3	1" DOUBLE X.H. PIPE	SEAMLESS STEEL	CUT FROM 1 PC. 2' LONG		
6	6	[illegible]	[illegible]	6	-2	1" DIA. X 5 1/4" LONG	STEEL	ROD	CUT FROM 1 PC. 3'-0" LONG	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-1	1 1/4" X 1/4" X [illegible] LONG	"	BAR	CUT FROM 1 PC. [illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23	HANDLE			COMPLETE	
2	2	2	2	2	-4	1/4" STD. PIPE PLUG	M.I.	[illegible]		
2	2	2	2	2	[illegible]	1" STD. PIPE PLUG	"	"		
2	2	2	2	2	-2	1" X 1" X 1/4" TEE	"	"		
FT. 2	FT. 2	FT. 2	FT. 2	FT. 2	-1	1" X.H. PIPE	SEAMLESS STEEL		CUT TO SUIT	
2	2	2	2	2	22	COMBUSTION CONT. CONN.			COMPLETE	
FT. 10	FT. 10	FT. 10	FT. 10	FT. 10	-5	1 1/4" X 1/4" FLAT BAR	STEEL	CUT TO SUIT	[illegible]	
2	2	2	2	2	[illegible]	1/4" X.H. COUPLING	STEEL		[illegible]	
2	2	2	2	2	-4	3/8" STD. PIPE PLUG	M.I.			
4	4	4	4	4	-3	1 1/4" DIA. X 1/4" THICK	STEEL	PLATE	[illegible]	
2	2	2	2	2	-2	1 1/4" STD. WT. PIPE	SEAMLESS STEEL		[illegible]	
2	2	2	2	2	-1	1/4" X.H. PIPE	"		[illegible]	
2	2	2	2	2	[illegible]	CO_2 GAS CONN.			COMPLETE	
2	2	[illegible]	2	2	20	PYROMETER CONN.	STEEL	[illegible] BAR	[illegible]	
[illegible]	[illegible]	[illegible]	2	2	-3	1" STD. PIPE PLUG	M.I.	[illegible]		
[illegible]	2	2	2	2	-2	1" X 1" X 1/4" TEE	"	"		
FT. 2	FT. 2	FT. 2	FT. 2	FT. 2	-1	1" X.H. PIPE	SEAMLESS STEEL	CUT TO FIT		
2	2	2	2	2	[illegible]	DRAFT GA. CONN.			COMPLETE	
2	2	2	2	2	-2	1/4" X.H. PIPE COUP.	STEEL		[illegible]	
FT. 2	FT. 2	FT. 2	FT. 2	FT. 2	-1	1/4" X.H. PIPE	SEAMLESS STEEL		CUT TO FIT	
[illegible]	2	2	[illegible]	2	[illegible]	THERMOMETER CONN.			COMPLETE	
NO. OF PIECES					PC. NO.	NAME OF PART	MAT'L	PATT. NO.	REMARKS	D. NO.



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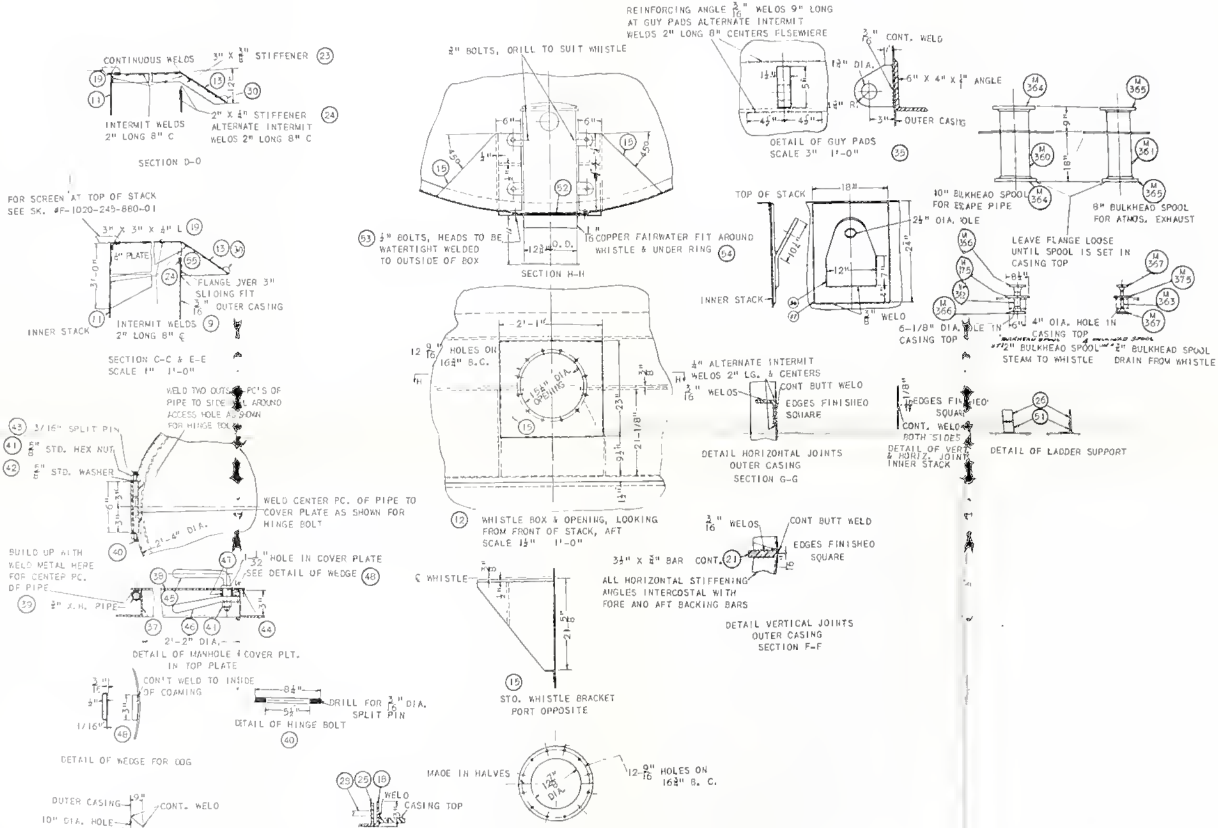
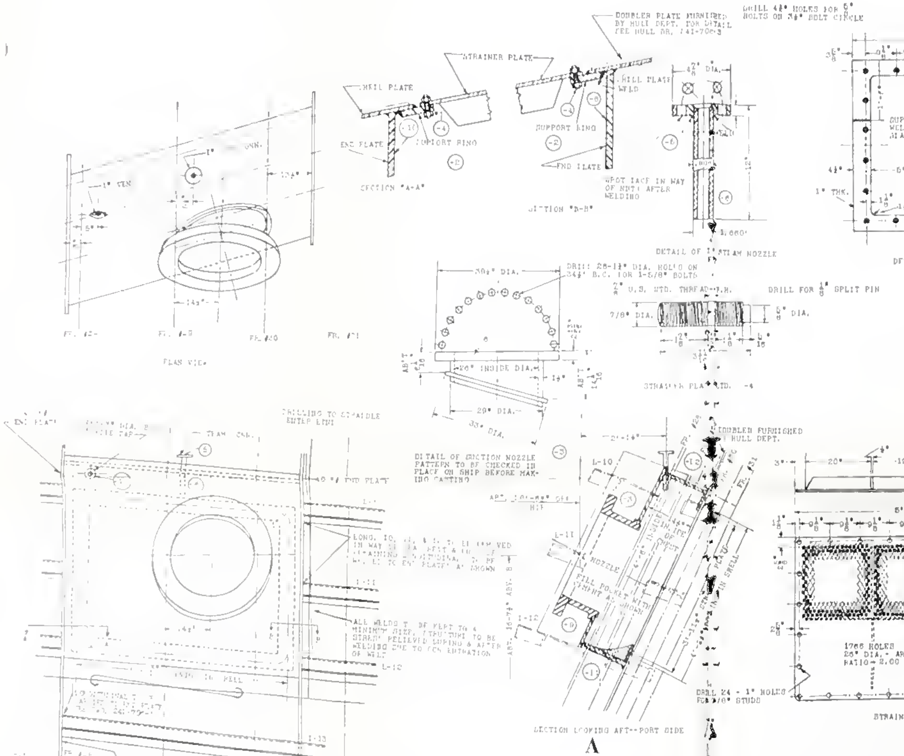


DRAWING NO. 241-880-4



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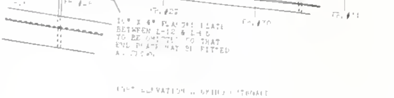

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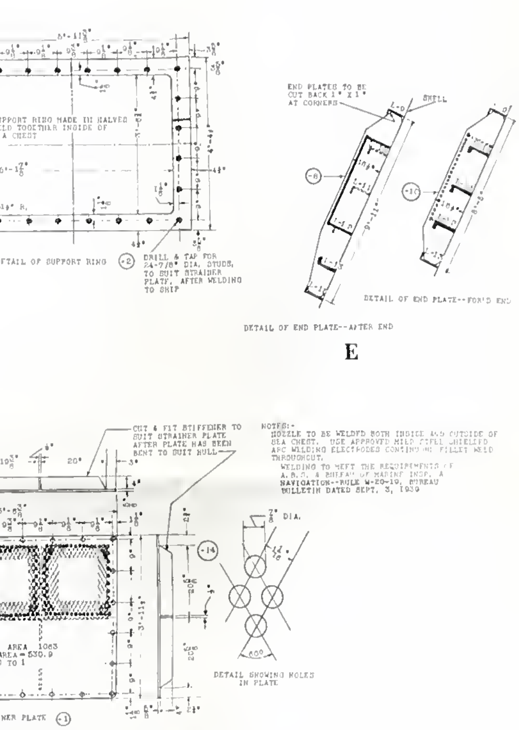


E

BILL OF MATERIAL

NO. P...	PC. NO.	NAME OF PART	MAT'L	PATT. NO.	REMARKS	DR. NO.
12 FT.	-14	STIFFENER	TANK STEEL		6" X [illegible] TK.	241-901-20
1	-13	1" WELD PAD	TANK STEEL		4" O.D. X 1" THK.- P.T.	241-901-20
1	-12	TOP PLATE	"	CUT TO SUIT	7'-0" X 18" X 1" THK.	"
1	-11	BOTTOM PLATE	"	" " "	7'-0" X 18" X 1" THK.	"
1	-10	END PLATE	"	" " "	9'-0" X 20" X 1" THK.	"
1	-9	FRONT PLATE	"	" " "	7'-0" X 6'-0" X 1" THK.	"
1	-8	END PLATE	TANK STEEL	CUT TO SUIT	10'-6" X 60" X 1" THK.	"

BILL OF MATERIAL (CONT'D)

NO. PCS.	PC. NO.	NAME OF PART	MAT'L	PATT. NO.	REMARKS	DR. NO.
24	-7	1/8" SPLIT PIN	BRASS		1 1/4" LONG	[illegible]
1	-6	1" DOUBLE X-HVY PIPE	STEEL	11 1/4" LONG	1" STEAM CONN.	"
1	-5	1" X-HVY FLANGE	STEEL PLATE	1/2" THK.	" "	"
24	-4	7/8" STUDS	STAINLESS STEEL	WITH 2 STD. BRASS NUTS	3-11/16" LONG	"
1	-3	26" SPOOL	C.S. ANNEALED	241-901-1-3		"
1	-2	SUPPORT RING	TANK STEEL		6'-11 3/8" X [illegible] 1" THK.	"
1	-1	STRAINER PLATE	STEEL PLATE	GALV.	5'-6 3/8" X 3'-11 1/4" X 1/4" THK.	"
1	1	26" SEA CHEST		COMPLETE		241-901-20

DRAWING NO. 241-901-20

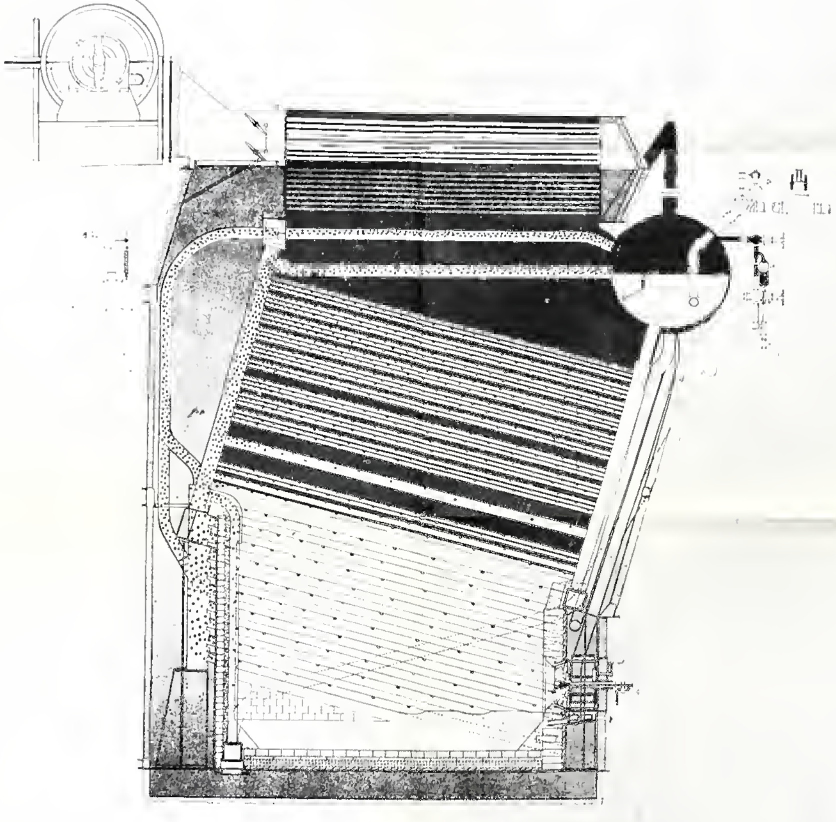
BILL OF MATERIAL FOR SMOKESTACK

Materials Listed Here Are for the Parts Shown on Drawings Nos. 241-880-3 and 241-880-4

NO. PCS.	PC. NO.	NAME	MAT'L	PATT.	REMARKS
	4 4 4 8	PLT. 288" x 96" x 1/4"	Steel		Outer Casing Bottom Courses
	4 4 4 9	PLT. 288" x 72" x 3/16"	Steel		Outer Casing Top Courses
	2 2 2 10	PLT. 260" x 84" x 1/4"	Steel		Inner Casing Bottom Courses
	3 3 3 11	PLT. 240" x 72" x 1/4"	Steel		Inner Casing Top Courses & Brackets
	3 3 3 12	PLT. 220" x 60" x 3/16"	Steel		Stack Top and Whistle Box
	2 2 2 13	PLT. 264" x 84" x 3/16"	Steel		Canopy
	3 3 3 14	PLT. 168" x 48" x #10 B.W.G.	Steel		Air Inlet Cowl Top and Sides
	1 1 1 15	PLT. 144" x 48" x 1/2"	Steel		Whistle Supports
	175 175 175 16 FT. FT. FT.	6" x 4" x 3/8" Angle	Steel		Reinforcing Stiff.
	200 200 200 17 FT. FT. FT.	3 1/2" x 3" x 1/4" Angle	Steel		Outer Casing Horiz. Butt Stiff.
	200 200 200 17 FT. FT. FT.	3" x 2 1/2" x 1/4" Angle	Steel		Outer Casing Internal Stiffeners
	30 30 30 19 FT. FT. FT.	3" x 3" x 1/4" Angle	Steel		Braces
	75 75 75 20 FT. FT. FT.	3" x 3" x 1/4" Angle	Steel		Outer and Inner Stack Base
	650 650 650 22 FT. FT. FT.	3" x 1/4" Flat Bar	Steel		Vert. Stiff.
	75 75 75 23 FT. FT. FT.	3" x 3/8" Flat Bar	Steel		Stack Top Stiff.
	50 50 50 24 FT. FT. FT.	2" x 1/4" Flat Bar	Steel		Outer Casing Top Edge Stiffener
	110 110 110 25 FT. FT. FT.	2 1/2" x 3/8" Flat Bar	Steel		Grating
	115 115 115 26 FT. FT. FT.	2 1/2" x 1/2" Flat Bar	Steel		Ladder Sides
	65 65 65 27 FT. FT. FT.	3/4" Dia. Rod	Steel		Ladder Rungs
	250 250 250 28 FT. FT. FT.	3/8" SQ. Bar	F.S.		Grating
	40 40 40 29 FT. FT. FT.	2" Half Round	F.S.		Inlet Hood Edge Stiffener
	62 62 62 30 FT. FT. FT.	3" Half Round	F.S.		Canopy Edge Stiff.
	1 1 1 31	Door	F.S.		Door Complete
	11 11 11 32	Stanchion Head	F.S.	Die #80	Grab Rail Stack Top
	50 50 50 33 FT. FT. FT.	3/4" Pipe Galv.	Seamless Steel	STD. WT.	Grab Rail Stack Top
	4 4 4 34	PLT. 30" x 12 x 1/4"	Steel		Inner Casing Guide
	1 1 1 35	PLT. 5" x 1 1/2" x 1 1/2"	Steel		Guy Pads
	2 2 2 36	Cut From PC #11	Steel		Grating Plate
	1 1 1 37	Cut From PC #11	Steel		Manhole Ring
	1 1 1 38	PLT. 30" x 30" x 3/16"	Steel		Manhole Cover
	1 1 1 39	3/4" X.H. Pipe	Seamless Steel		For Hinges
	1 1 1 40	5/8" Dia. Bolt 8 1/4" Long	Steel	Thread Both Ends	For Hinges
	3 3 3 41	5/8" STD. Nut	Steel		For Hinges and Dog
	2 2 2 42	5/8" STD. Washer	Steel		For Hinges
	2 2 2 43	5/16" STD. Split Pin	Steel		For Hinges
	8 8 8 44 FT. FT. FT.	3/16" x 3/4" Bar	Steel		Cover Flange
	1 1 1 45	Dog	F.S.	Die #74	Cover Handle
	1 1 1 46	Dog Handle	F.S.	Die #75	Cover Handle
	1 1 1 47	Spacer	Steel		1 1/2" O.D. x 1 1/32" I.D. x 9/16" THK.
	1 1 1 48	1/2" x 3/4" Bar	F.S.	3" Long	Wedge
	7 7 7 49	Handrail Stanchion	F.S.	Die #107, #108	A 2'-10"
	30 30 30 50 FT. FT. FT.	1" Pipe Galv.	Seamless Steel		Handrail
	4 4 4 51	Cut From PL. #15	Steel		Angle Clips
	1 1 1 52	Cut From PC. #12	Steel		Whistle Cover Ring
	12 12 12 53	1/2" Bolts 1 1/2" Long	Steel		Whistle Cover Ring
	1 1 1 54	PLT. 58" x 6" x 1/16"	Copper		Rainwater Fit Around Whistle
	1 1 1 55	Cut From PC. #11	Steel		Top Brackets
	1 1 1 56	PLT. 54 x 18" x 1/4"	Steel		Lifting Pad
30 30 30 FT. FT. FT.	M-353	10" STD. Pipe	Seamless Steel		Escape Pipe
30 30 30 FT. FT. FT.	M-354	8" STD. Pipe	Seamless Steel		ATM. Exhaust
20 20 20 FT. FT. FT.	M-355	2" STD. Pipe	Seamless Steel		STM. to Whistle
22 22 22 FT. FT. FT.	M-356	3/4" STD. Pipe	Seamless Steel		Drain From Whistle
2 2 2	M-357	3/4" Elbows	M.I.	Screwed	Drain From Whistle
1 1 1	M-358	3/4" Lateral	M.I.	Screwed	Drain From Whistle
1 1 1	M-359	3/4" Ell	M.I.	Screwed	Drain From Whistle
2'-6" 2'-6" 2'-6"	M-360	10" x X.H. Pipe	Seamless Steel		Escape Pipe
2'-6" 2'-6" 2'-6"	M-361	8" X.H. Pipe	Forged Steel		ATM. Exhaust
1 1 1 FT. FT. FT.	M-362	2" X.H. Pipe	Forged Steel		STM. to Whistle
1 1 1 FT. FT. FT.	M-363	3/4" X.H. Pipe			Drain From Whistle
5 5 5	M-364	10" Slip on Flange	Forged Steel	125# STD.	For Escape Pipe PC. #M-353
5 5 5	M-365	8" Slip on Flange	Forged Steel	125# STD.	For ATM. Exhaust Pipe PC. #M-354
2 2 2	M-366	2" Weld. Neck Flange	Forged Steel	150# STD.	For STM. to Whistle Pipe PC. #M-362
2 2 2	M-367	3/4" Weld. Neck Flange	Forged Steel	150# STD.	For Drain From Whistle Pipe PC. #M-363
1 1 1	M-368	2" Screwed Flange	Forged Steel	300# STD.	For STM. to Whistle Pipe PC. #M-355
1 1 1	M-369	2" x 1 1/2" Reducing Flange	Forged Steel	300# Special	For STM. to Whistle Pipe PC. #M-372
1 1 1	M-370	2" Screwed Flange	Forged Steel	150# STD.	For STM. to Whistle Pipe PC. #M-355
1 1 1	M-371	3/4" Screwed Flange	Forged Steel	150# STD.	For Drain From Whistle Pipe PC. #M-356
3 3 3 FT. FT. FT.	M-372	1 1/2" STD. Pipe	Seamless Steel		STM. to Whistle
1 1 1	M-373	PLT. 15" x 9" x 1/2"	Steel		Bulkhead Spool
	4 4 4 57	Cut From PC. #11	Steel		Lifting Pad Stiffener

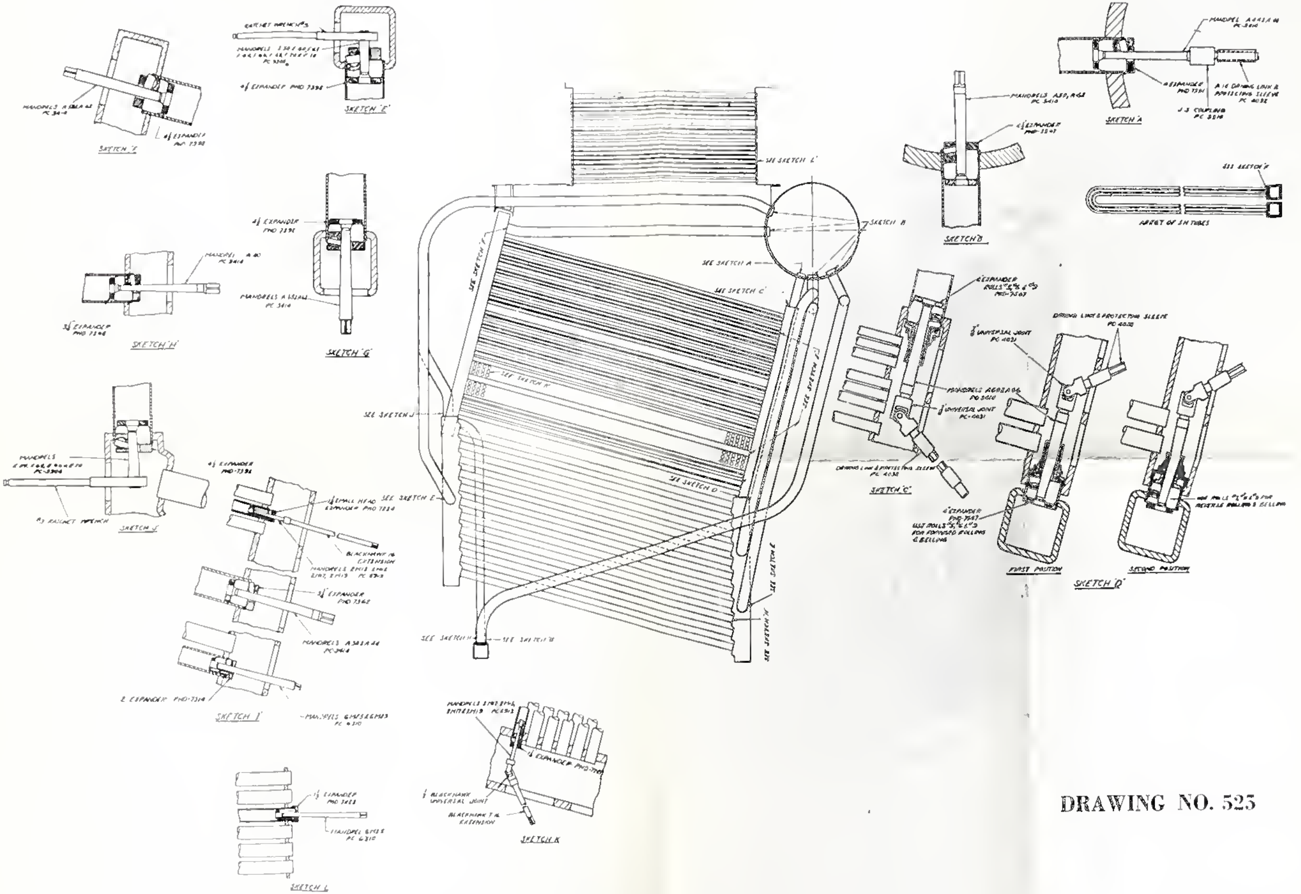
LIST OF PARTS FOR G9B HEAD (CHAIN OPERATED) SOOT BLOWER

DETAIL NO.	NO. REQ'D.	NAME OF PIECE	MATERIAL
1		Gooseneck (Clockwise Rotation)	Cast Steel
2		Gooseneck (C.C.W. Clockwise Rotation)	Cast Steel
5	1	Valve Disc	Monel
6	1	Valve Seat	Monel
7	1	Valve Stem	Monel
8	1	Valve Stem Retainer Nut 1 1/4" Hex.	Monel
9	1	Valve Stem Packing Nut 1 1/2" Hex.	Brass
10	1	Valve Stem Guide 1 1/4" Hex.	C.R.S.
11	1	Valve Spring	Spring STL.
12	1	Valve Spring Retainer	STL. Stamp
13	1	Valve Yoke	STL. Stamp
14	1	Valve Yoke Pin	Steel
16	1	Valve Retainer Washer	Monel
17	1	Valve Lift Pin	C.R.S.
18	1	Valve Guide Washer	COP. and ASB.
19		Valve Stem Packing Ring	
20	1	Sheave Wheel	Mall. Cast
21	1	Chain Guide	Mall. Cast
22	1	Pinion 8-10 Pitch — 11 Teeth	C.R.S.
23	1	Gear 8-10 Pitch — 80 Teeth	Cast Iron
24	1	Cam	STL. Stamp
25	3	Special Cam Bolt	S.F.S.
26	1	Cam Trigger	STL. Forg.
27	1	Trigger Fulcrum Clevis Pin	Steel
28	1	Wheel End	SS. Tube
29	1	Swivel End	N.C. Metal
30	1	Swivel Tube Assembly	
31	1	Sleeve Bearing	S.S. Tube
32	1	Sleeve Bearing Tie Bolt	Steel
33	1	Bushing For No. 34	Bronze
34	1	Bracket	STL. Stamp.
35	1	Bracket Stud	C.R.S.
36	2	Spacer For No. 32	C.R.S.
37	1	Lower Distance Piece	C.R.S.
38	1	Washer	C.R.S.
39	1	Swivel Tube Packing Gland	Cast Iron
40	2	T Bolt	D.F.S.
41	4	Swivel Tube Packing Ring	Garlock No. 1005
42	1	Stuffing Box (Floating)	Mall. Cast.
43	1	Floater Spring Screw	C.R.S.
44	1	5/8" S.A.E. Hex Nut 5/16" Thick	Steel
45	1	Floater Spring	SPG. Steel
46	1	Gland	Cast Iron
47	3	Packing Ring 1/4" Sq. or Round	Asbestos Rope
48	2	Thrust Washer	Steel
49	1	Ball Retainer	Steel
50	10	3/8" Diameter Ball	Steel
51	1	Bearing Assembly	
52	1	Orifice Disc	All F.G. 33 FM Type Fig. or Equal
53	2	Companion Flange Gasket	Copper Asbestos
54	1	Air Relief Valve	Corr. Resist Steel
55	2	3/8" Hex. HD. Pipe Plug Yngt # 2172 or Equal	C.R.S.
57	2	1 1/2" Shoulder Nut	Steel
58		Companion Flange 1 1/2" Size	Forg. STL.
59		Companion Flange 2" Size	Forg. STL.
60		Companion Flange 2 1/2" Size	Forg. STL.
64	2	Stud 2" LG.	C.R.S.
65	2	Straight Fitting Mod. #F3 Short Nut and 1#33 Union Anderson Br. Co.	
66	5	1/2" STD. Washer	Steel
67	3	Spring	SPG. Steel
68	2	5/16" — 18 Wing Nut	Steel
69	2	5/16" — 18 Hex. HD. Bolt 1 3/4" long	Steel
70	2	1/2" — 13 Stud 2 1/2" long	C.R.S.
71	1	Gasket	Asbestos
72	1	Reinforcing Plate	Steel
73	2	1/4 x 20 Hex HD. Bolt 3/4" LG.	Steel
74	2	1/4 x 20 Hex Nut	U.S.S.S.F.
75		3/8" O.D. Tubing 032 Wall	Copper
76	6	Stud	Simplex Steel
77	1	Cotter Pin 1/8" x 1 1/4" For No. 32	Steel
78	3	Cotter Pin 3/32" x 1" For No. 27&40	Steel
79	1	Cotter Pin 3/32" x 1/2" For No. 13	Steel
80	1	Lockwasher 5/16" (Shake Proof)	SPG. STL.
81	3	Lockwasher 3/8" (Shake Proof)	SPG. STL.
82	1	Bristo Screw 3/8" x 1/4" For No. 30	U.S.S.C.R.D.
83	1	Bristo Screw 3/8" x 3/8" For No. 20	U.S.S.C.R.D.
84	1	R.D.L.S. Screw 3/8" x 1 1/4" For No. 23	U.S.S.C.R.D.
85	2	Oval Fill. HD. Screw 3/8" x 3/8" For No. 24	U.S.S.C.R.D.
86	1	Shoulder Bolt	Steel
87	2	Cap Screw HX. HD. 1/2" x 1 1/2" For No. 34	U.S.S.S.F.
88		3/4" Street Ell	Mall Iron
89	1	Hex. Nut 1/2" (Slotted) For No. 32	U.S.S.S.F.
90	1	Hex. Nut 5/16" For No. 17	U.S.S.S.F.
91	3	Hex. Nut 3/8" For No. 24	U.S.S.S.F.
92	3	Hex. Nut 1/2" For No. 40 and 35	U.S.S.S.F.
93	12	Hex. Nut 3/4" For Comp. Flange	U.S.S.S.F.
94	10	Check Nut 1/2" For No. 35	U.S.S.S.F.
95	1	Check Nut 3/8" For No. 23	U.S.S.S.F.



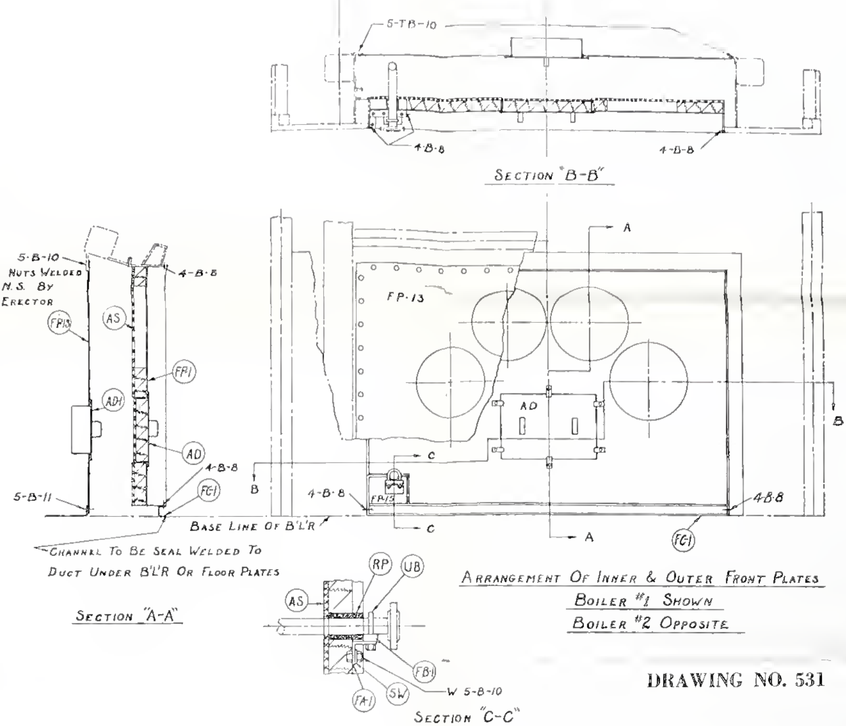
BABCOCK & WILCOX
SECTIONAL-HEADER SINGLE-PASS
MARINE BOILER

DRAWING NO. 463



DRAWING NO. 525

METHOD OF EXPANDING TUBES & NIPPLES
WITH EXPANDERS IN POSITION



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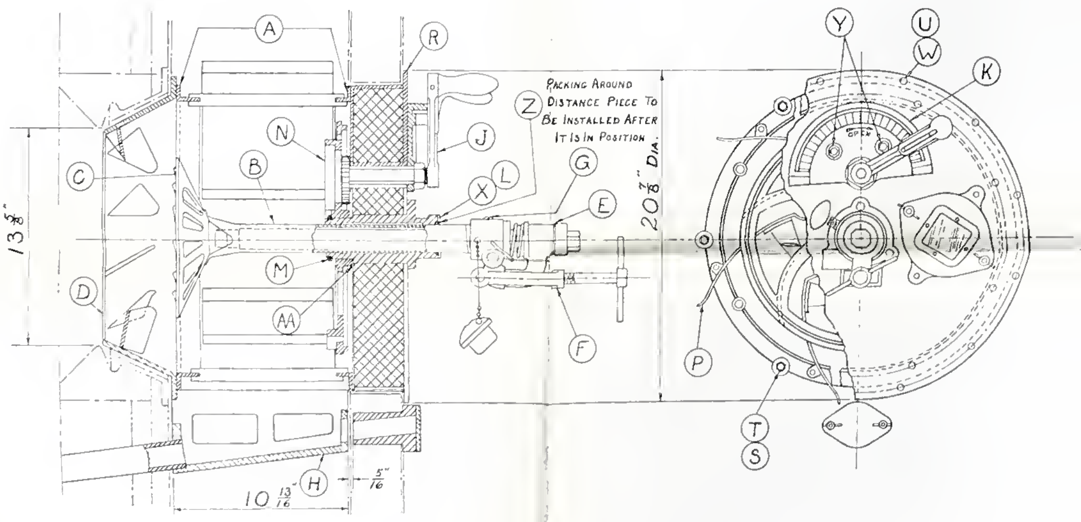

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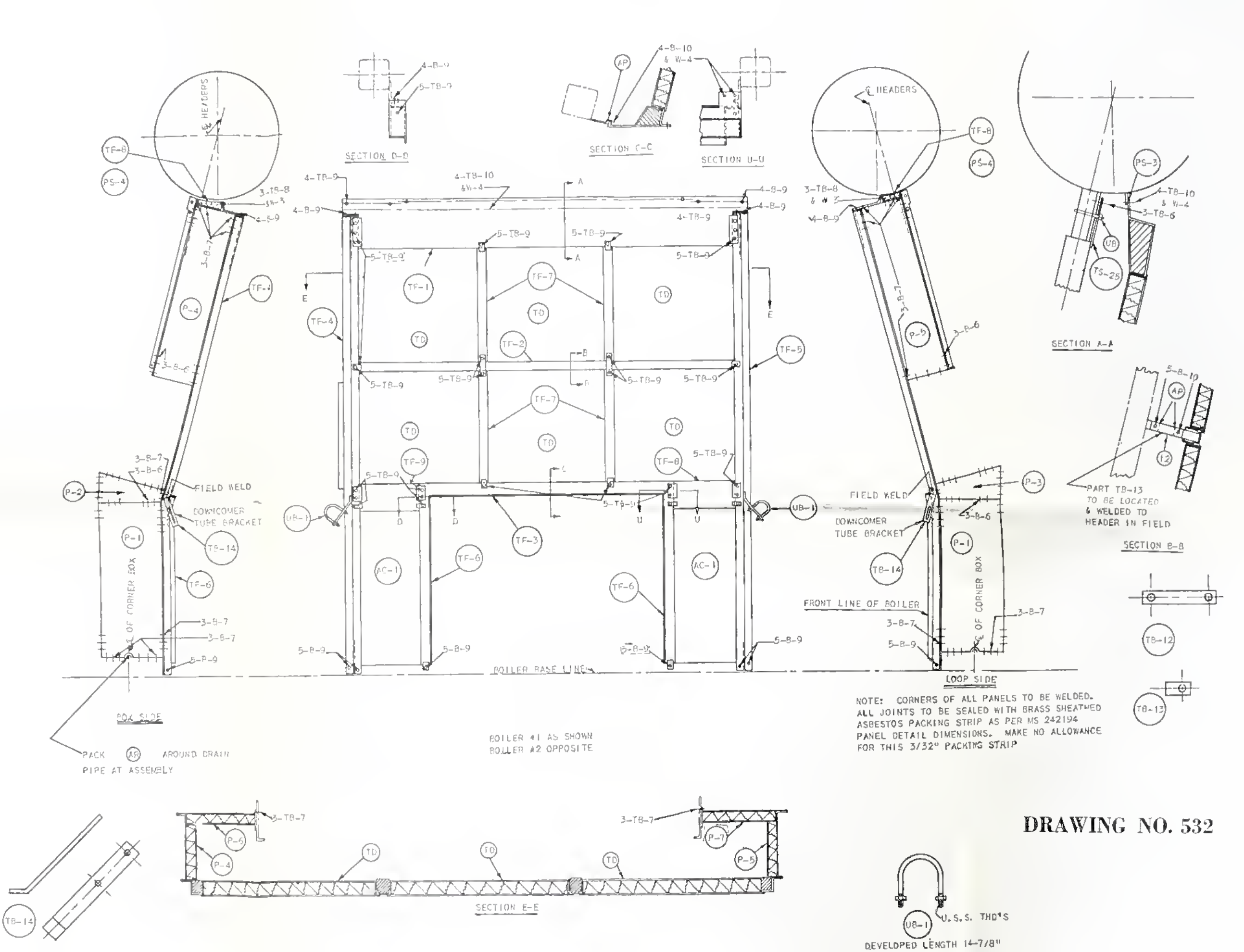

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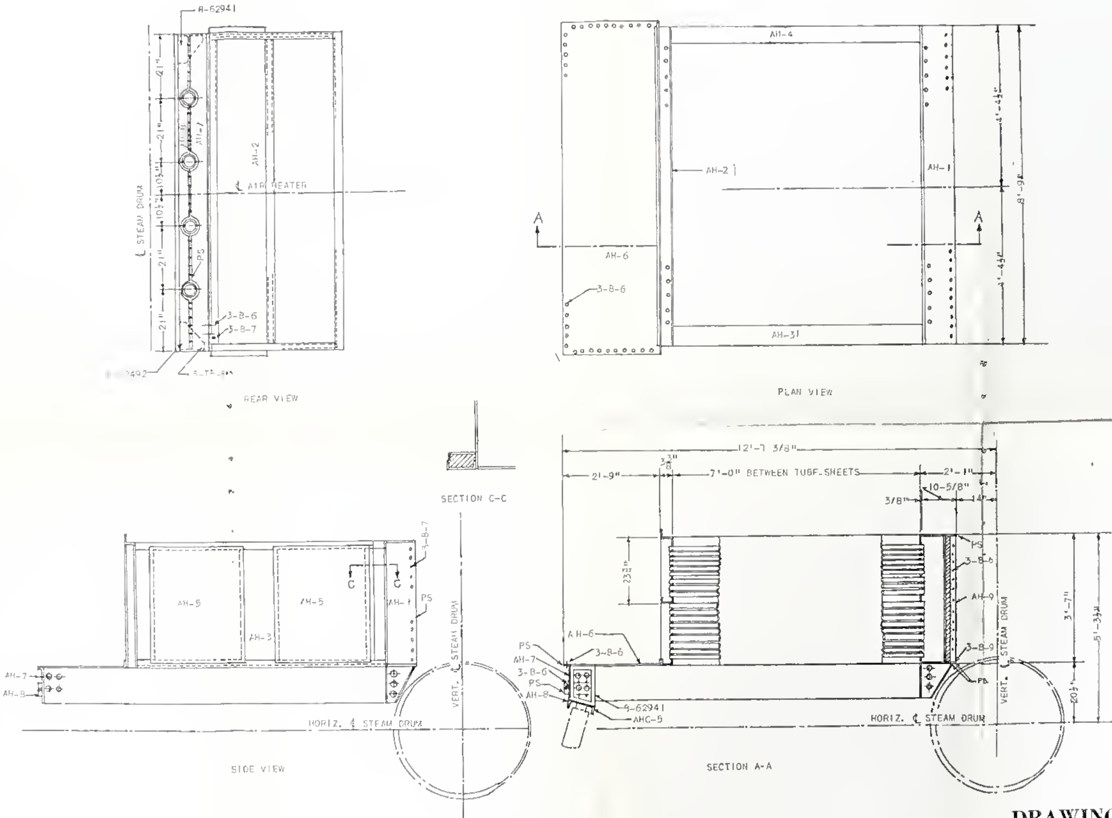

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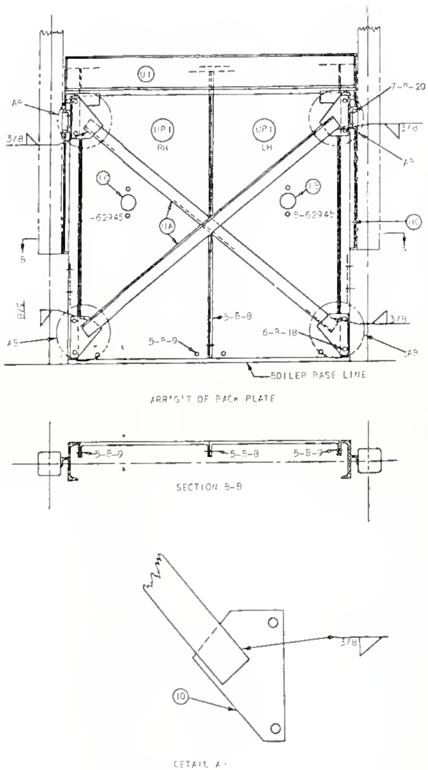

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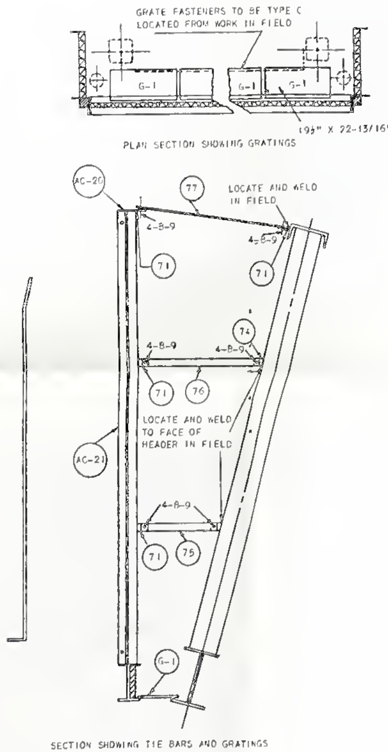

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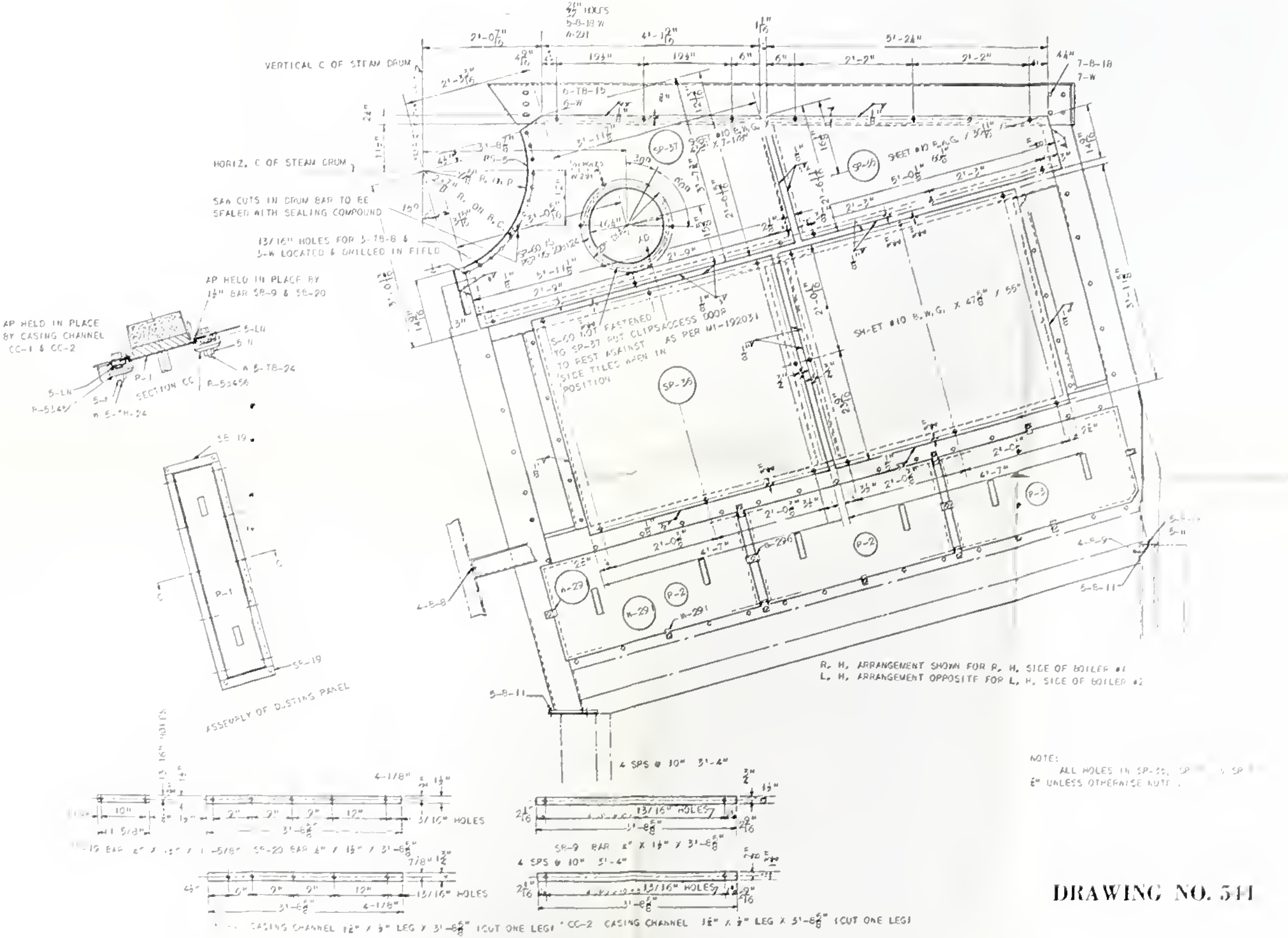

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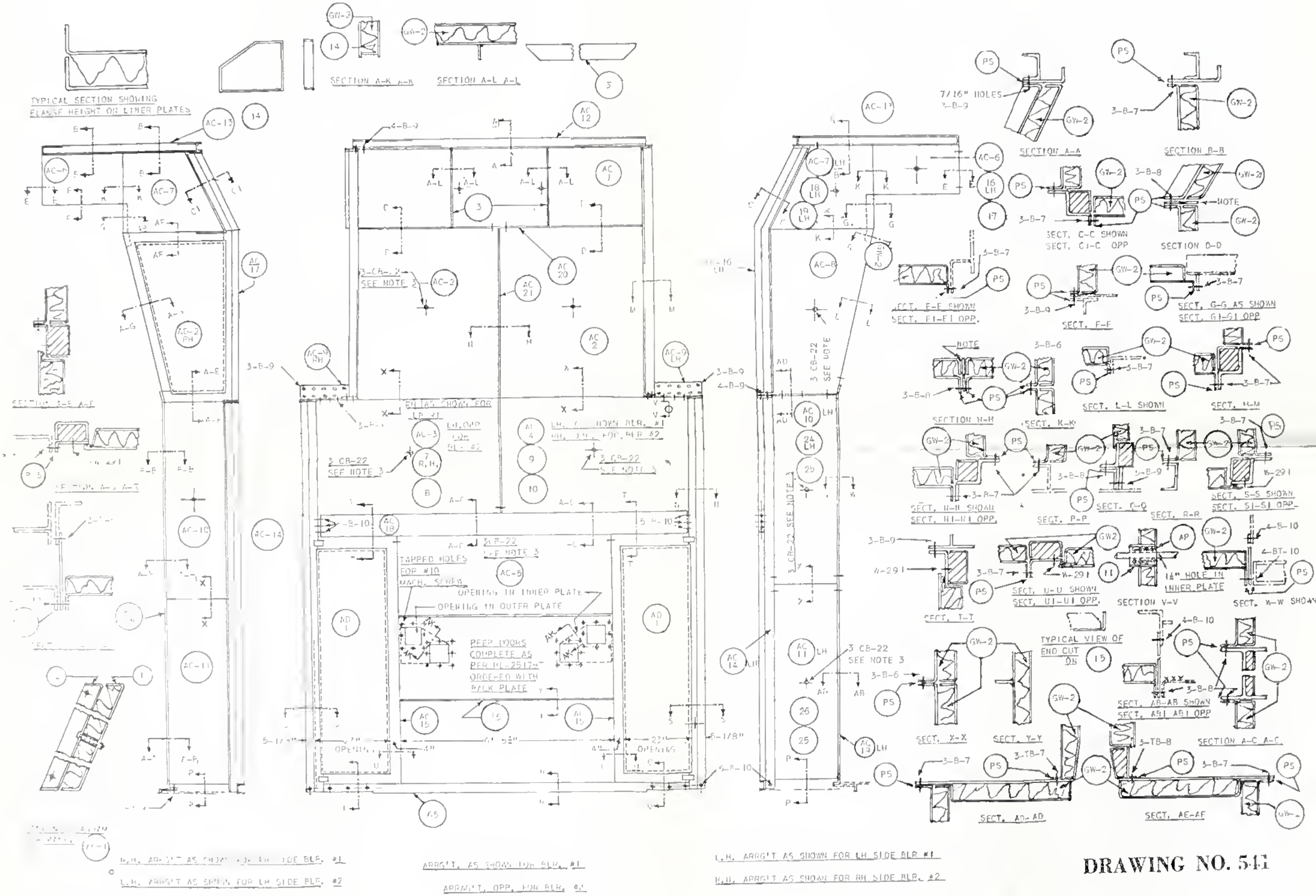

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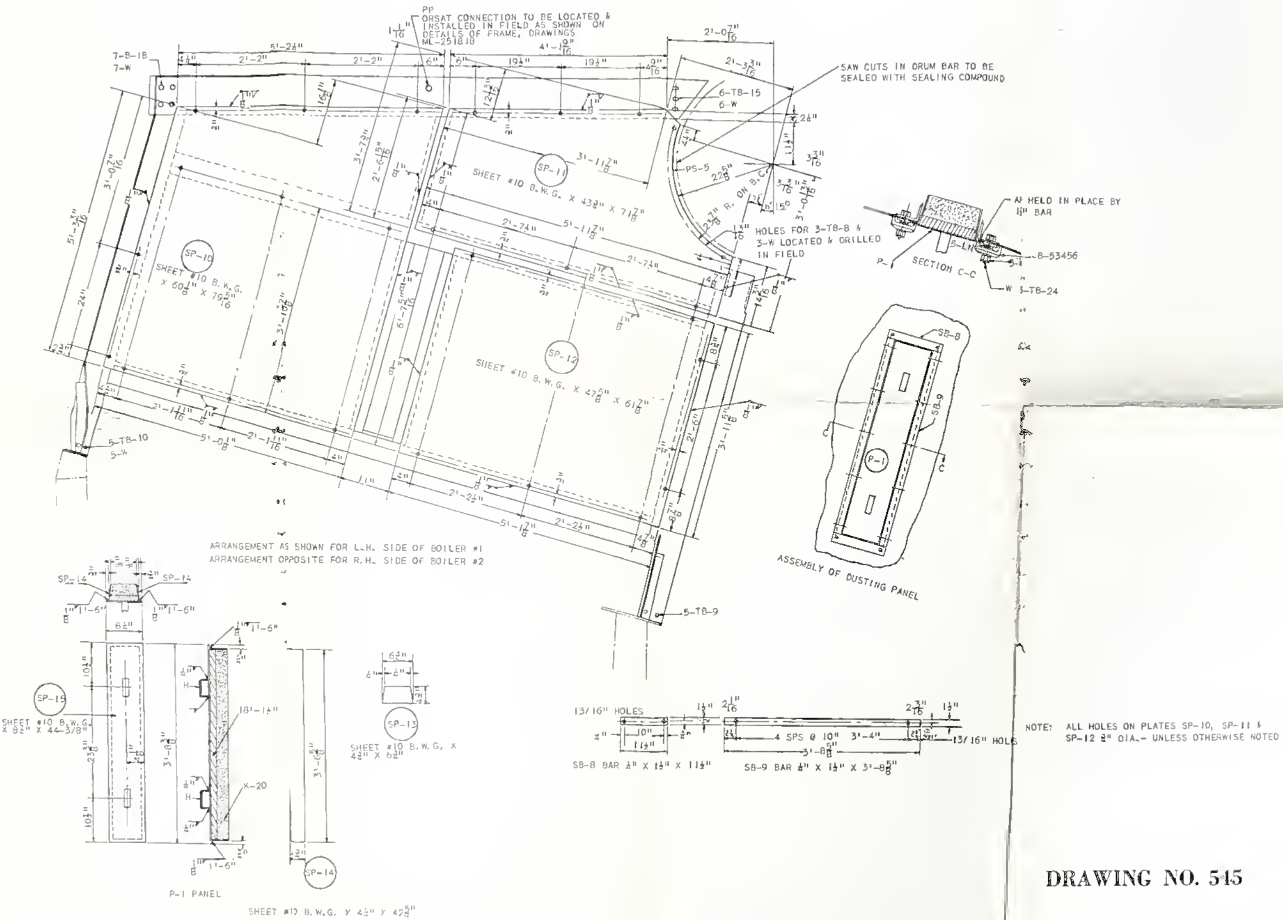

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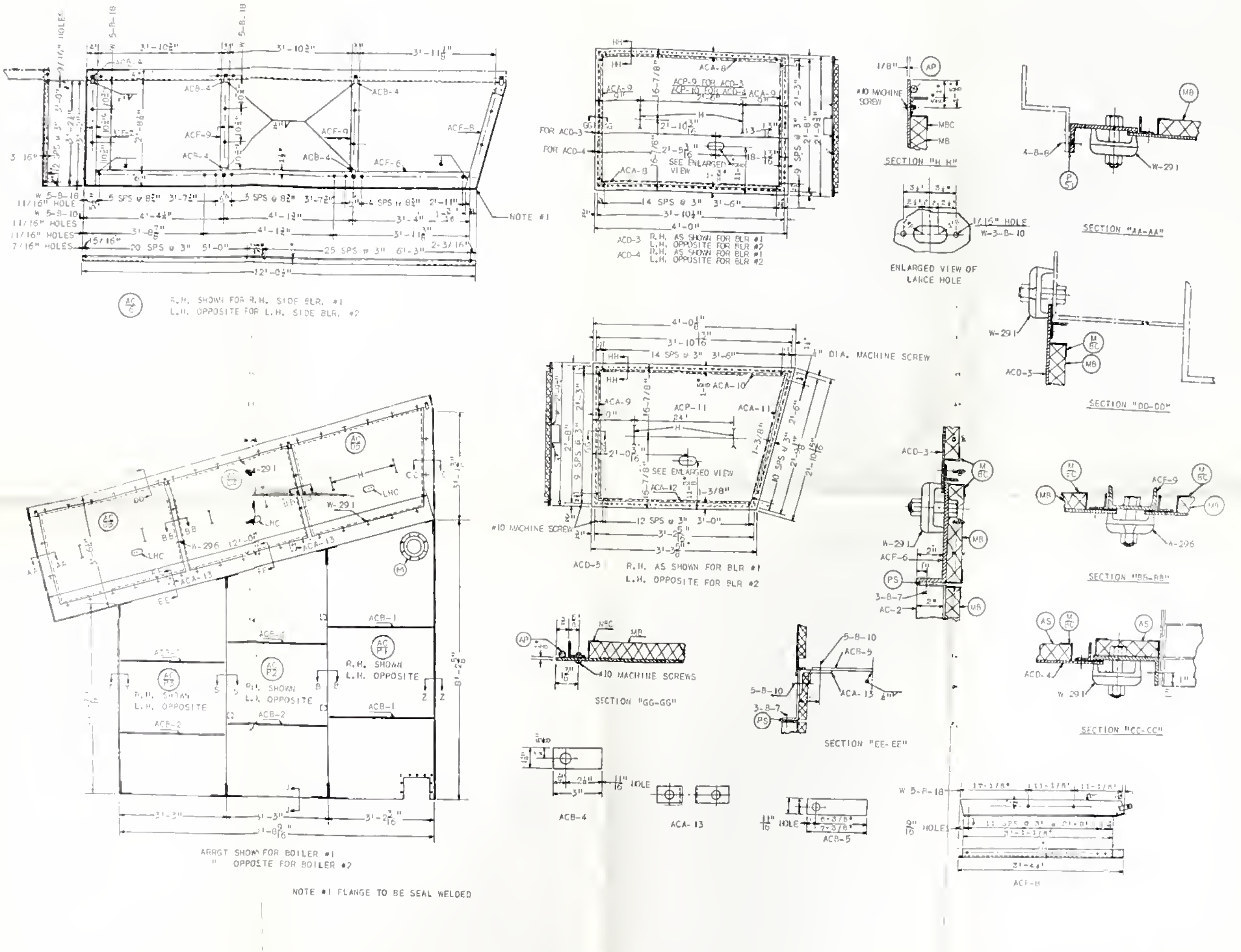

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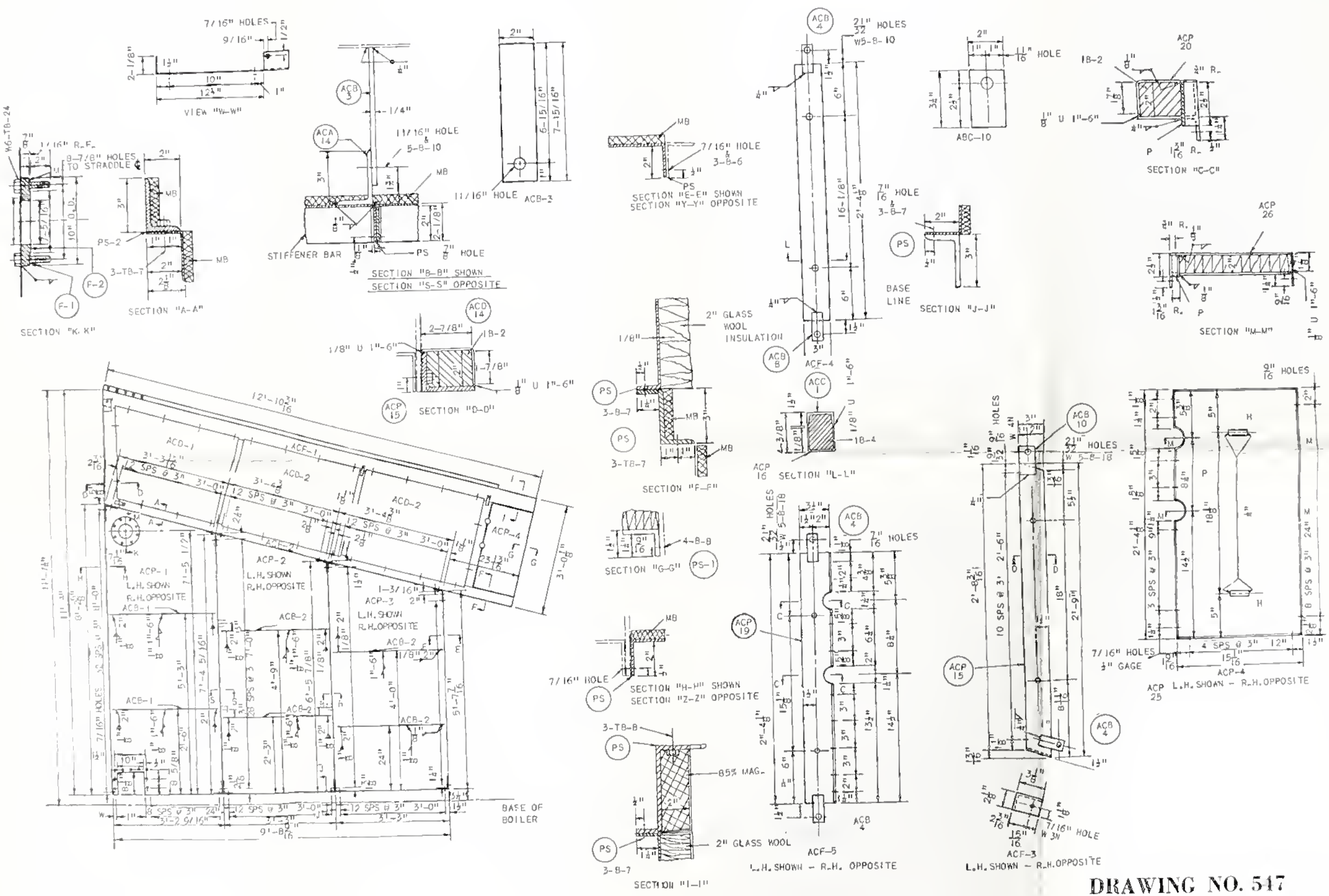

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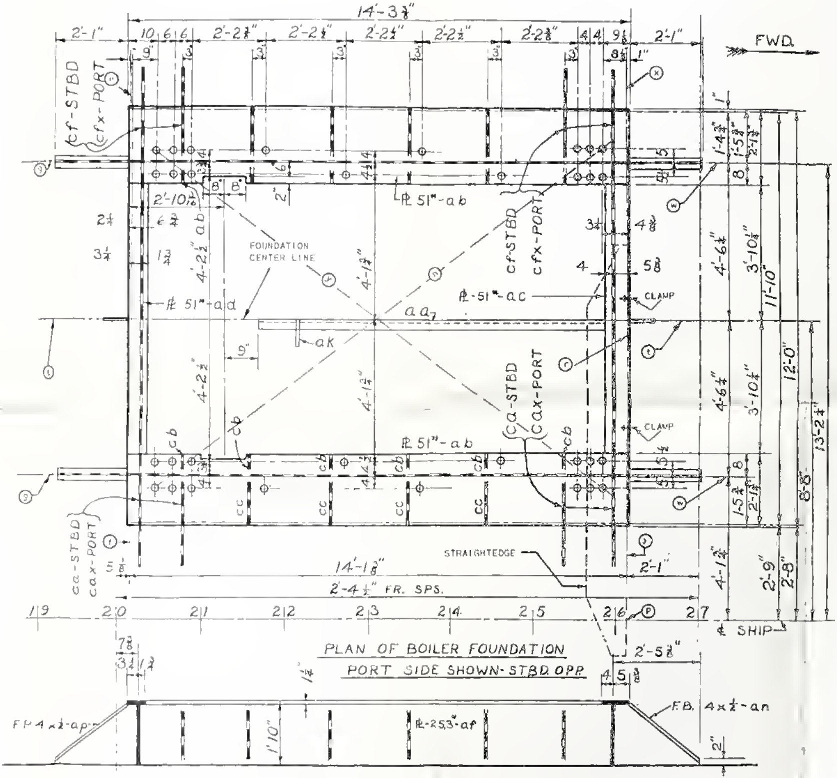
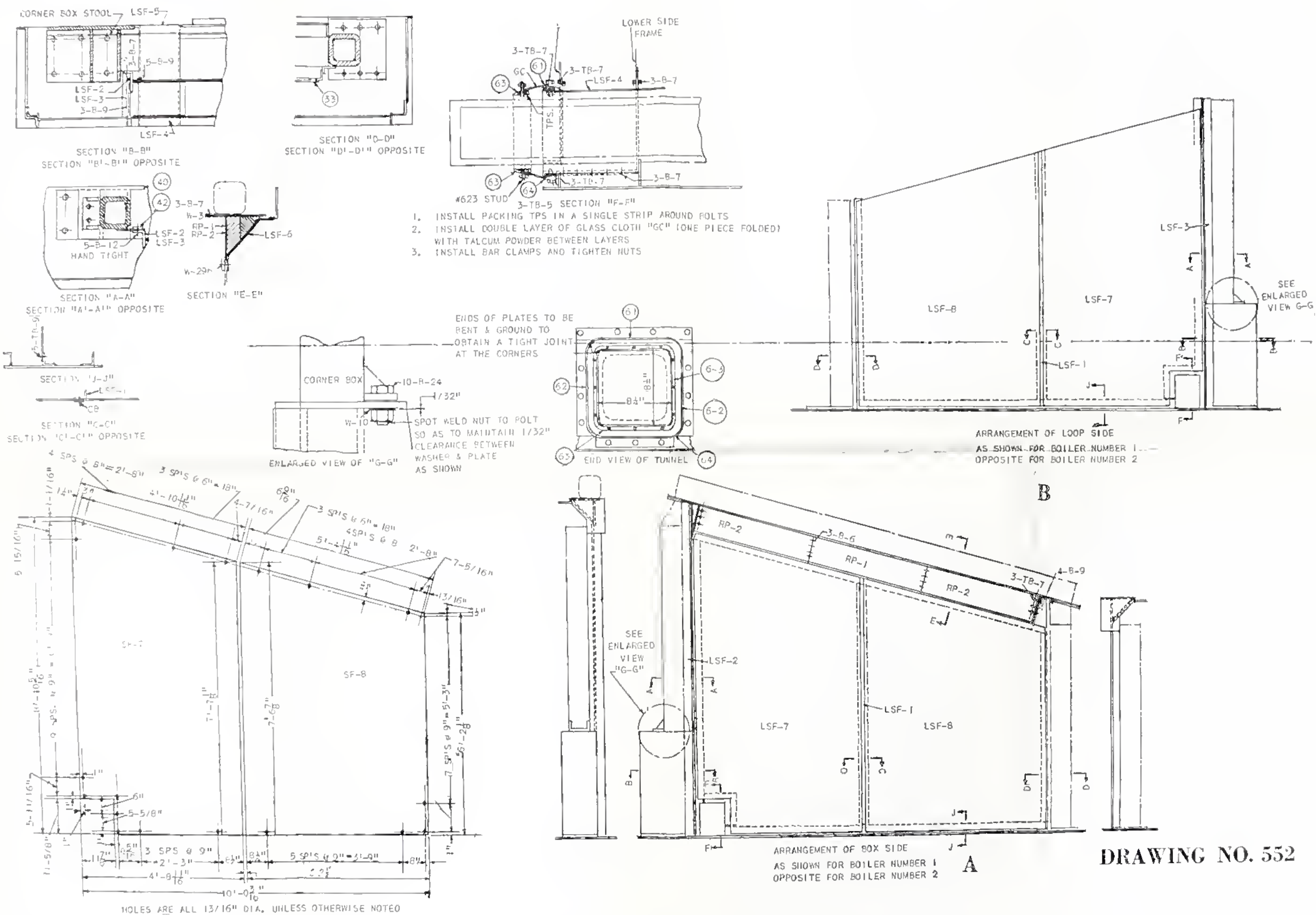


DRAWING NO. 550 BOILER FLAT



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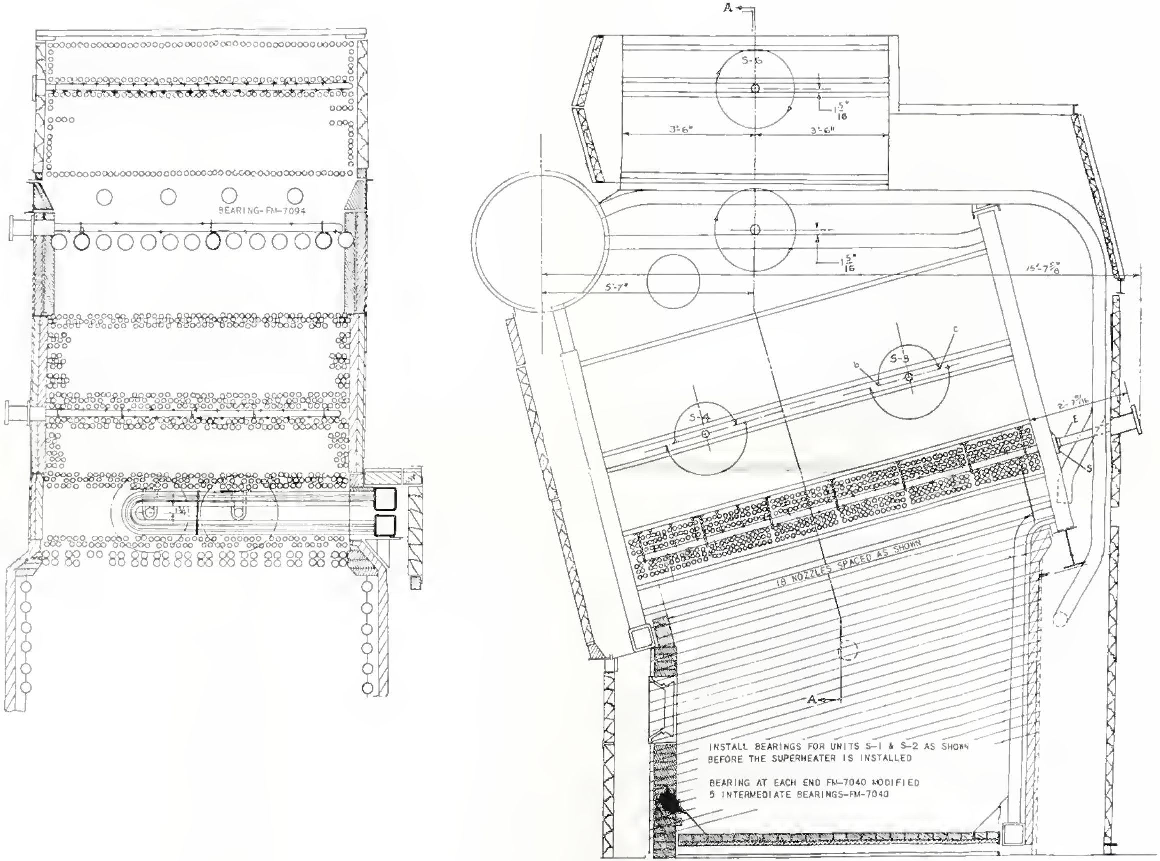

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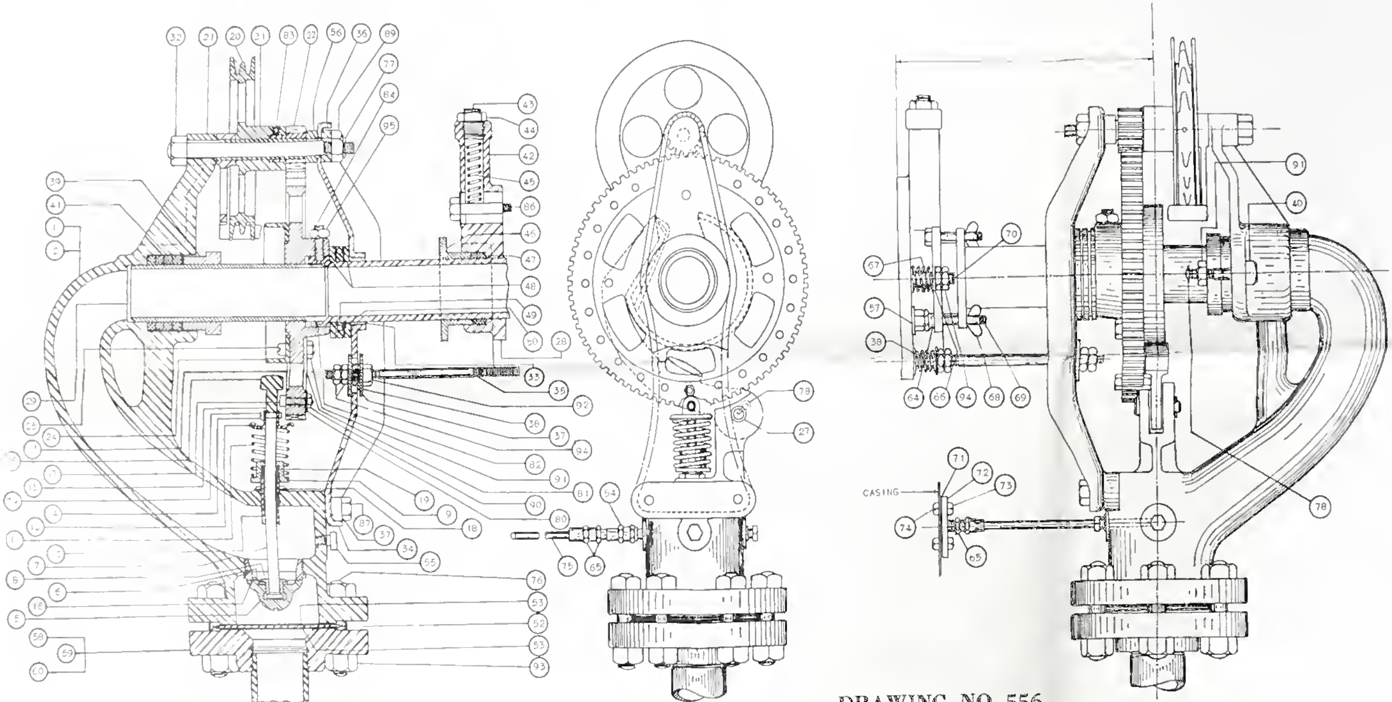

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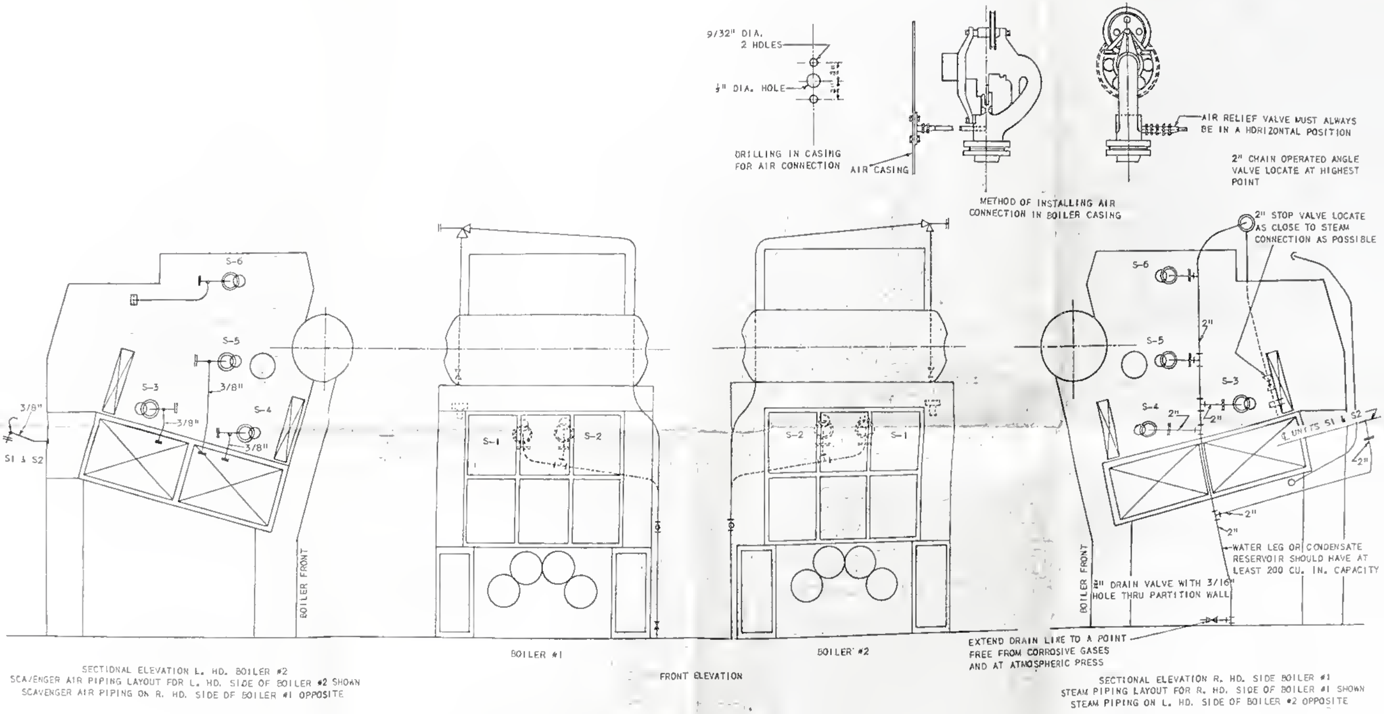
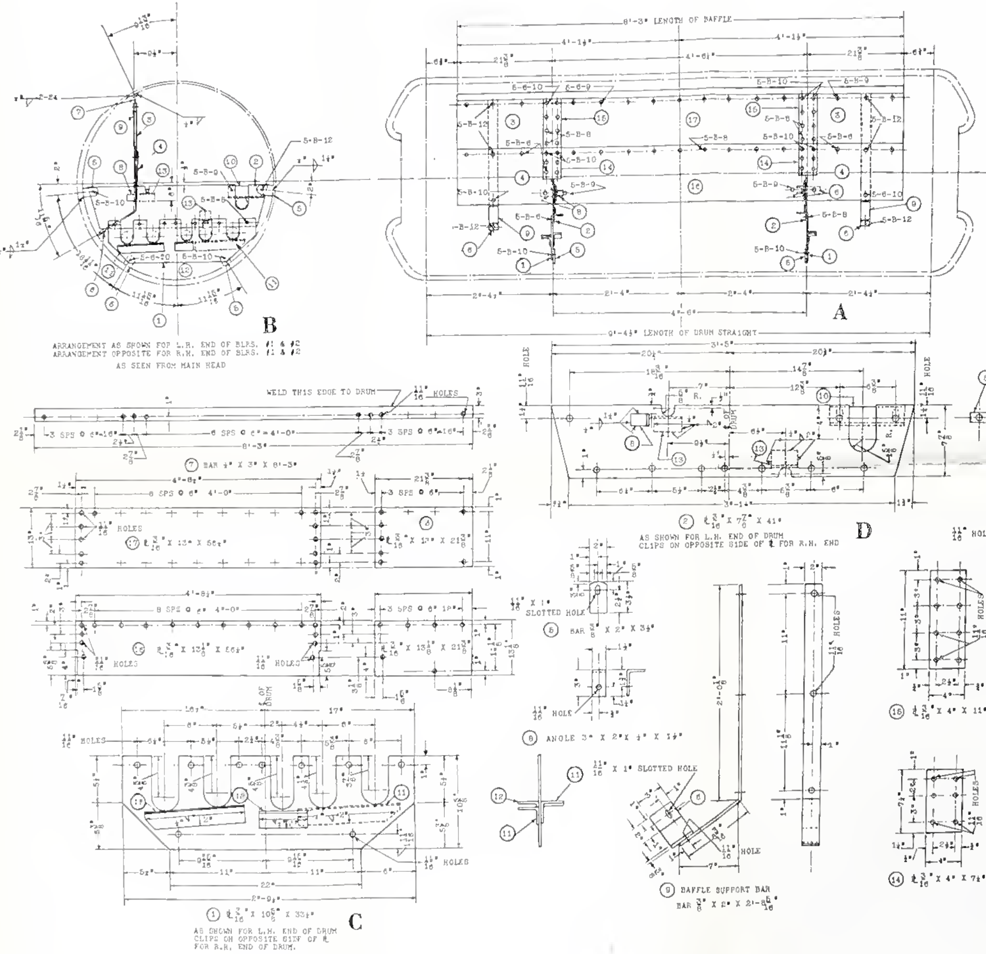
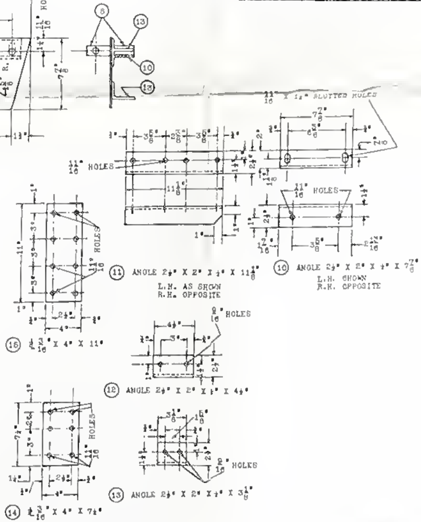


NOTE: PIPE VALVES AND FITTINGS ARE NOT FURNISHED BY D. P. S. CORP. AND ARE SHOWN FOR THE CUSTOMERS CONVENIENCE ONLY

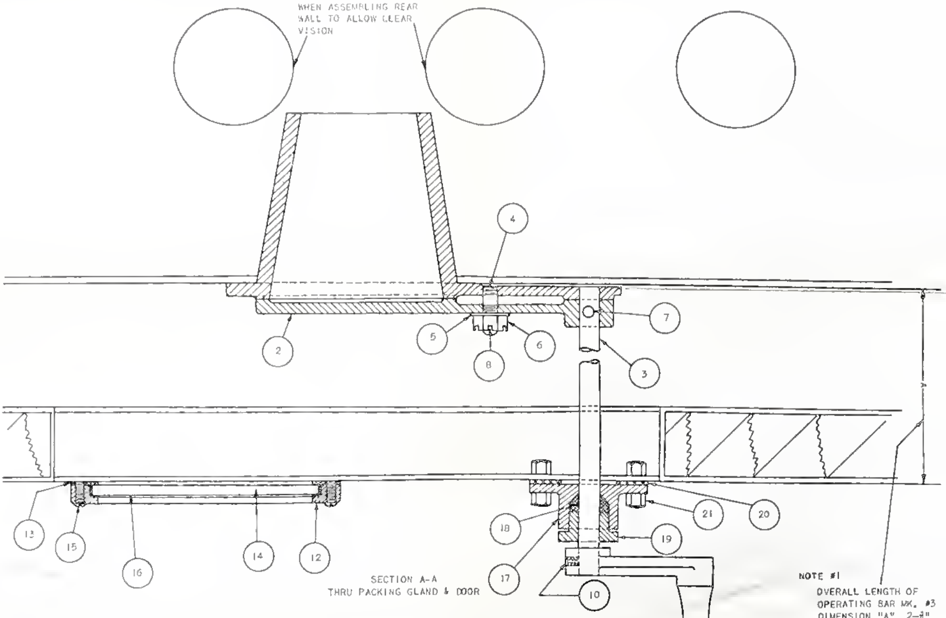
DRAWING NO 557



MR'K	AMT.	DESCRIPTION	MAT.	SHEET	REMARKS
LIST OF MATERIAL FOR ONE CL'R					
1	2	P 3/16" X 10-5/8" X 33-1/4"	STEEL		
2	2	" 3/16" X 7-7/8" X 41"	"		
3	2	" 3/16" X 13" X 21-3/8"	"		
4	2	" 3/16" X 13-1/8" X 21-3/8"	"		
5	8	BAR 3/8" X 2" X 3-1/2"	"		
6	2	" 3/8" X 2" X 3"	"		
7	1	" ½" X 3" X 8'-3"	"		
8	4	ANGLE 3" X 2" X ½" X 1½"	"		
9	2	BAR 3/8" X 2" X 2' - 8-5/16"	"		
10	2 (1R-1L)	ANGLE 2½" X 2" X ½" X 7-7/8"	"		
11	4 (2R-2L)	" 2½" X 2" X ½" X 11-1/8"	"		
12	2	" 2½" X 2" X ½" X 4½"	"		
13	4	" 2½" X 2" X ½" X 3-1/8"	"		
14	2	P 3/16" X 4" X 7½"	"		
15	2	P 3/16" X 4" X 11"	"		
16	1	P 3/16" X 13-1/8" X 56½"	"		
17	1	P 3/16" X 13" X 56½"	"		
	106	5/8" HEX. NUTS- C.P.S.F. (CASE H"D"N)	"		
5-B-8	43	HEX. HD. BOLTS 5/8" X 1"	STEEL		
5-B-9	19	" " " 5/8" X 1-1/8"	"		
5-B-10	16	" " " 5/8" X 1¼"	"		
5-B-12	8	" " " 5/8" X 1½"	"		
	10	U-BOLTS FOR 2½" PIPE 5/8" X 10-11/16" LG.	"	C-58456	
	2	" " " 2" " ½" X 9½" LG.	"	"	
	4	" " " 1½" " ½" X 5-5/16" LG.	"	"	
	12	½" HEX. NUTS-C.P.S.F. (CASE H"D"N)	"		

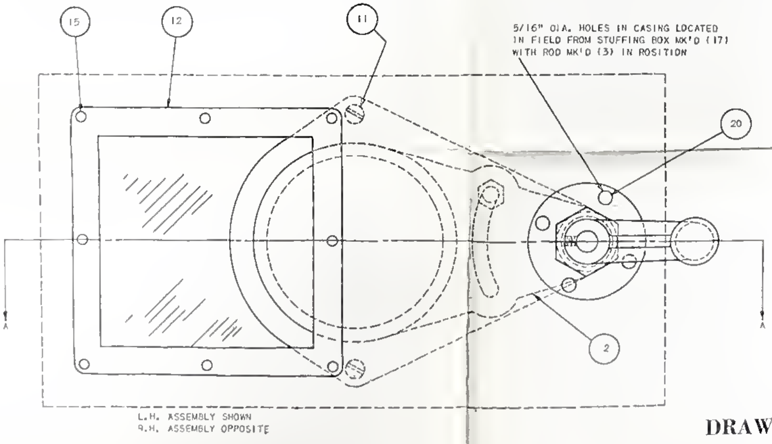


DRAWING NO. 558



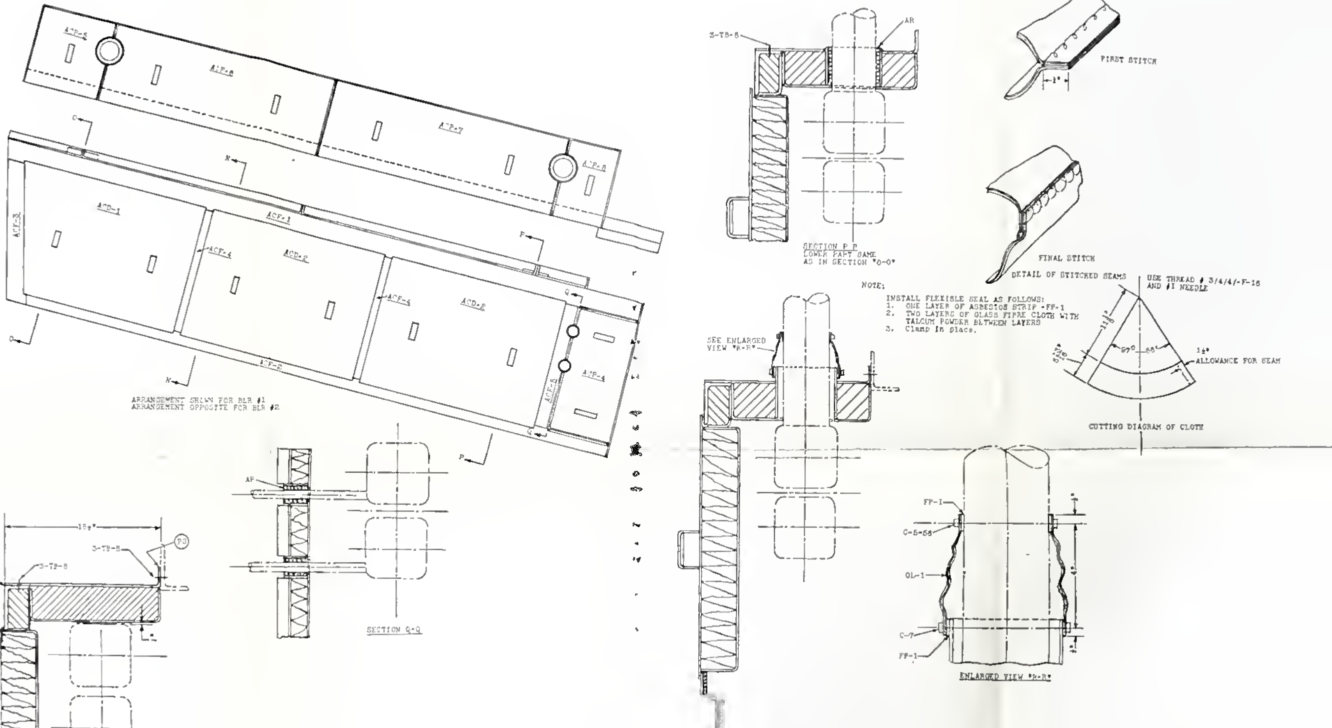
LIST OF MATERIAL REQUIRED FOR ONE DOOR					
AMT.	MK.	DESCRIPTION	MATERIAL	DRAWING	REMARKS
					COMPLETE
1	1D	DOOR SLEEVE PATT. B-62945	GREY IRON	ML-242612	L.H. SIDE ONLY
1	1E	" " " "	"	"	R.H. SIDE ONLY
1	2	COVER PLATE " B-58560	"	"	
1	3	ROD 5/8" DIA.	STEEL	"	SEE NOTE #1 FOR LENGTH
1	4	STUD 3/8" DIA. X 1 1/4" LONG	"	"	
1	5	WASHER 7/16" I.D. X 1" O.D. X .078" THK.	"		
1	6	CASTLE NUT C.P.S.F. 3/8" 24-NF-3	"		
1	7	COTTER PIN 1/8" DIA. X 1 3/4" LONG	"		
1	8	" " 3/32" DIA. X 1" "	"		
1	9	LEVER ARM PATT. 62350	CAST STEEL	ML-242612	
1	10	HEADLESS SET SCREW 1/4" DIA. X 3/8" LONG 20-NC-3	STEEL		
2	11	FLAT HD. MACH. SCREW 3/8" DIA. X 1" LONG 16-NC-2	"		
1	17	STUFFING BOX	STEEL	ML-242612	
1 FT.	18	BRAIDED PACKING 1/4" SQ.	ASBESTOS		
1	19	PACKING NUT	STEEL	ML-242612	
1	20	GASKET 1/16" THK X 3 1/2" DIA.	ASBESTOS	"	
4	21	HEX.HD.BOLTS 1/2" DIA. X 3/4" LG. & HEX NUTS	STEEL		

MATERIAL REQUIRED FOR EACH OBSERVATION PANEL					
AMT.	MK.	DESCRIPTION	MATERIAL	DRAWING	REMARKS
1	12	GLASS RETAINER (PATT B-58561)	GREY IRON	ML-242612	
1	13	GASKET 1/16" THK. X 7" SQ.	ASBESTOS	"	ALUM. JACKET
1	14	PYREX CLASS 1/4" THK. X 6-3/8" SQ.			
8	15	RD.HD.MACHINE SCREWS #10 X 3/4" LG. 24-NC-2	STEEL		
1	16	GASKET 1/16" THK. X 6-7/16" SQ.	ASBESTOS	ML-242612	ALUM. JACKET



VIEW OF PEEP DOOR WITH ONE OBSERVATION PANEL

DRAWING NO. 559



LIST OF MATERIAL-QUANTITIES ARE FOR ONE BOILER-FLEXIBLE SEALS					
MARK	AMT.	DESCRIPTION	MAT'L	SHEET	REMARKS
GL-1	2	CLOTH-TYPE EC-9.65-136	GLASS FIBRE		CUT FROM PIECE 18" X 24"
	2 FT.	GLASS SEWING THREAD # 3/4/4/-F-16			
	2 OZ.	TALCUM POWDER (NON ACID BASE)			
C-5,56	1	GRIP-TITE CLAMP- #20 B.W.G. ½" X 19½" LG.	ELECTRO GALV. STEEL	S. S. K-236494	
C-7	1	GRIP-TITE CLAMP-#20 B.W.G. ½" X 27" LG.	"	"	
FP-1	3½ FT.	ASBESTOS STRIP-1" WIDE X 1/8" THK.	ASBESTOS		
	½ PT.	WHITE SHELLAC			

DRAWING NO. 560

3083